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RECORDS OF THE SOUTH AUSTRALIAN MUSEUM

VOLUME 26
1992

Published by the South Australian Museum,
North Terrace, Adelaide, South Australia 5000.

Museum Victoria
72060

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Volume 26(1) was published on 12 October 1992.
Volume 26(2) was published on 17 August 1993.

ISSN 0376–2750

THE OCCURRENCE IN AUSTRALIA OF THREE SPECIES OF PHORONIDA (LOPHOPHORATA) AND THEIR DISTRIBUTION IN THE PACIFIC AREA

CHRISTIAN C. EMIG & CARMEN ROLDÁN

EMIG, C. C. & ROLDÁN, C. 1992. The occurrence in Australia of three species of Phoronida (Lophophorata) and their distribution in the Pacific area. *Rec. S. Aust. Mus.* **26**(1): 1-8.

The phoronids *Phoronis psammophila* Cori and *Phoronopsis albomaculata* Gilchrist are recorded for the first time from both South Australia (Spencer Gulf) and New Caledonia (Nouméa lagoon), and the latter for the first time from New Zealand. A diagnosis is given for each species, as well as for *Phoronis australis* Haswell. The distribution of all three species in the Pacific Ocean, Southern and Western Australian waters is detailed.

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Of the ten known species of Phoronida, all have representative populations in the Pacific Ocean and seven have been recorded in Australian waters (Emig *et al.* 1977; Emig 1982a, b). Recent benthic surveys of Spencer Gulf and Nouméa lagoon have resulted in the first records of *Phoronis psammophila* and *Phoronopsis albomaculata* from South Australia and New Caledonia; the new material is listed below, together with details of the collecting stations. Previously unidentified material from New Zealand in the collection of Portobello Marine Laboratory proves upon reexamination to be the first New Zealand record of *Phoronopsis albomaculata.* In addition, examination of material of *Phoronis australis* in the South Australian Museum led to additional locality records of this species in Western Australia and Queensland. The Pacific occurrence of all three species is discussed below, and a brief diagnosis given of each.

Phoronis australis Haswell

Phoronis australis Haswell, 1883: 606.
Phoronis buskii McIntosh, 1888: 1.

Distribution in the Pacific Ocean (Fig. 1).

Japan : 3. Misaki (Ikeda 1902, 1903); 4. Kyushyu (Ishihawa 1977), Kii Peninsula (Uchida 1979). *China* : 6. Amoy, Qingdao (Wu & Ruiping 1980; Emig 1982a b). *Philippines* : 7. (McIntosh 1888; Cori 1939). *Vietnam* : 8. Nhatrang Bay (Kasyanov & Radashevsky 1987). *Australia* : 17. Waterman Bay, W. Aust., (coll. South Australian Museum; Fig. 1); 10. Southport, Queensland (coll. South Australian Museum; Fig. 1), Moreton Bay, Queensland (Emig 1977); 18. Houtman Abrolhos Is., W. Aust. (Emig 1982b); 12. Sydney, N.S.W. (Haswell 1883; Ponder 1971; Emig *et al.* 1977).

Diagnosis

Burrowing in tube-wall of cerianthids, generally of the genus *Cerianthus.* From the intertidal zone to 36 m depth.

Length in extension up to 200 mm, 2-5 mm in diameter. Colour in life: body pink; anterior body part and lophophore transparent or purple to black. Lophophore spiral with 2.5 to 3.5 coils on each side, 5-16 mm in length, 600-1 000 tentacles. Nephridia with two funnels (anal large, oral small), an ascendant branch only, nephridiopore opening on nephridial ridge at level of anus. Two giant nerve fibres (left one 5-13 μm in diameter; right one 3-13 μm in diameter). Longitudinal muscle bundles of bushy type; arrangement of longitudinal muscle bundles relative to four sub-divisions of metacoelom formed by mesenteries (i.e. clockwise left oral, right oral, right anal, left anal sub-divisions) represented by conventional formula of Selys-Longchamps (1907); the general formula is:

$$[43\text{-}87]\ \frac{14\text{-}29 \mid 13\text{-}27}{4\text{-}17 \mid 5\text{-}17}$$ and the mean formula is

$$64 = \frac{22 \mid 22}{11 \mid 9}.$$

Sexual reproduction hermaphroditic; embryos brooded in lophophoral cavity on mucous cord secreted by nidamental glands of type B (*i.e.* restricted to floor of lophophoral concavity with an extension along coils of lophophore on inner surface of tentacles and associated with two embryo masses); lophophoral organs small. Asexual reproduction by transverse fission.

Larva: unknown.

Remarks

The burrowing habits of *P. australis* are characteristic. The species lives in the tube-wall of cerianthid species, mainly of *Cerianthus.* No ecological data were available on the individuals. The specimens collected in Australian waters appear to have a higher number of longitudinal muscle bundles than those examined in Atlantic and Indian waters (Table 1).

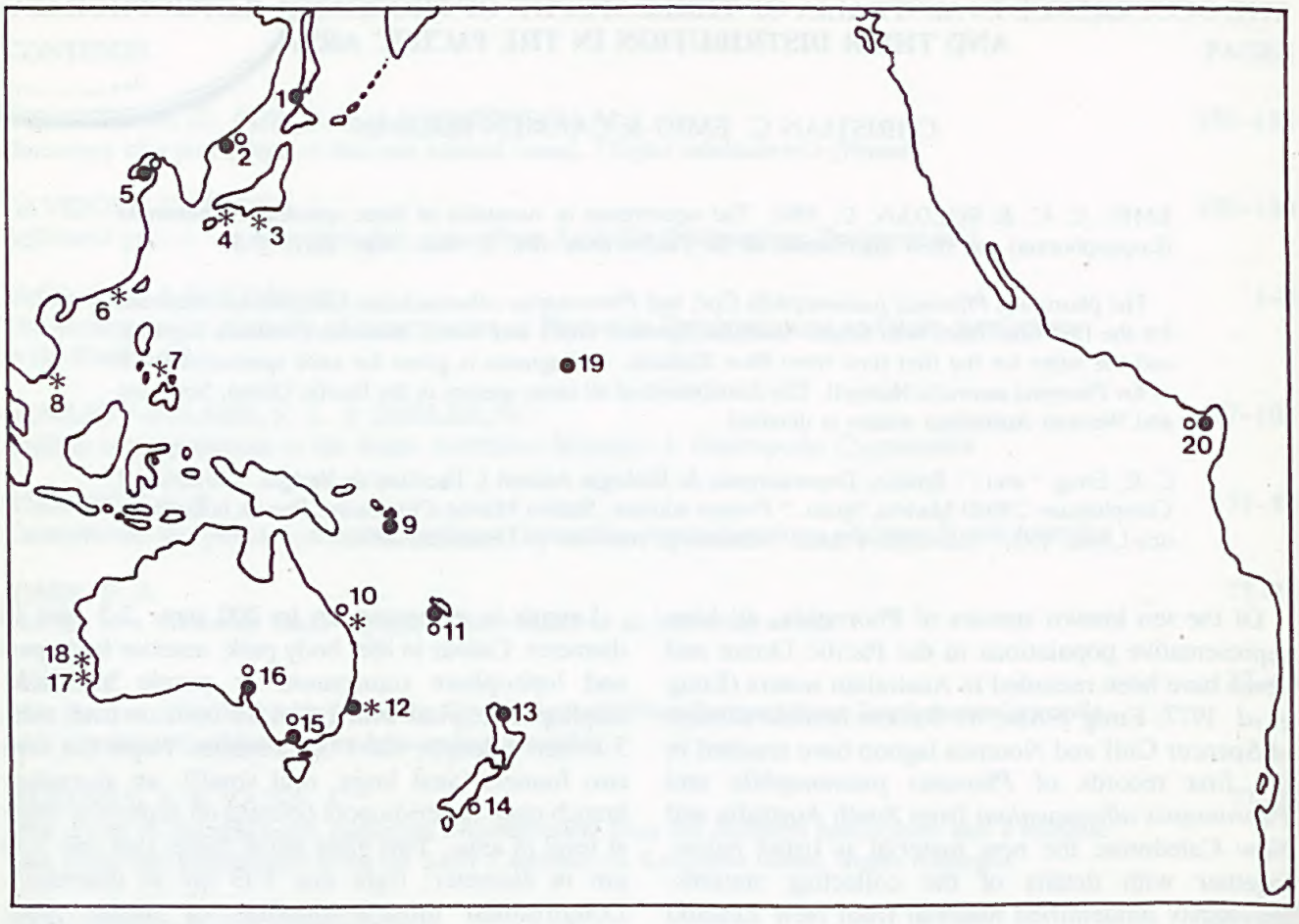

FIGURE 1. Occurrences of *Phoronis australis*, *P. psammophila* and *Phoronopsis albomaculata* in the Pacific Ocean (see explanation in text for location numbers and Tables 1, 4 and 5).

TABLE 1. Longitudinal muscle formulae of *Phoronis australis* recorded in Australian locations (see Fig. 1 for locations). N = number of specimens examined.

Locality	N	Mean		General Formula	
10. Southport	5	78	$= \frac{27 \mid 26}{14 \mid 11}$	$\frac{23-30 \mid 22-27}{12-15 \mid 10-14}$	[68–84]
10. Moreton Bay	1	65	$= \frac{23 \mid 22}{13 \mid 7}$		
12. Sydney	21	73	$= \frac{25 \mid 24}{13 \mid 11}$	$\frac{20-28 \mid 19-27}{8-17 \mid 7-17}$	[60–87]
17. Waterman Bay	1	59	$= \frac{21 \mid 19}{11 \mid 8}$		
Total for species	94	66	$= \frac{23 \mid 22}{12 \mid 9}$	$\frac{17-35 \mid 14-27}{4-17 \mid 5-19}$	[43–87]

Phoronis psammophila Cori

Phoronis psammophila Cori, 1889: 1.
Phoronis sabatieri Roule, 1889: 195.
Phoronis architecta Andrews, 1890: 445.

Distribution in the Pacific Ocean (Fig. 1).

Russia Far East: 1. Sakhalin (Emig 1984; Emig & Golikov 1990); 2. Poss'yet Bay, Mordinov Gulf (Emig 1984; Emig & Golikov 1990). *China*: 5. Changshan Is., Dalni, Potonoman (Emig 1984). *Solomon Is.*: 9. (Emig 1977). *Australia*: 12. Cabbage Tree Basin, N.S.W. (Rainer & Fitzhardinge 1981); 15. Port Phillip Bay, Western Port, Victoria (Emig *et al.* 1977); 16. Spencer Gulf, S. Aust. (coll. South Australian Museum; Fig. 2). *New Caledonia*: 11. Nouméa lagoon (coll. Emig; Fig. 3). *New Zealand*: 13. Ranganna Bay, Doubtless Bay (coll. D. P. Gordon); 13. Howick, Whangateau Harbor, Waitemata, Jellicoe (Jillett 1971; Gordon & McKnight 1983; coll. D. Gordon). *USA-Hawaii*: 19. Oahu (Emig 1977; Emig & Bailey-Brock 1987); 19. Midway (Sorden 1983). *Panama*: 20. (Emig 1982a).

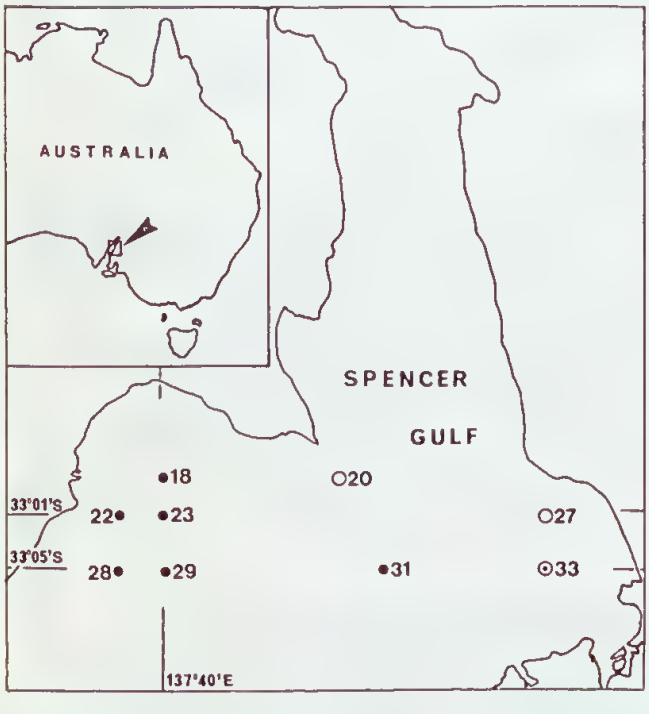

FIGURE 2. Map of the stations at which phoronid species have been recorded in Spencer Gulf (numbers correspond to station numbers of Table 2).

Diagnosis

Embedded vertically in soft sediments, generally sandy to muddy, or covered by seagrass beds. From the intertidal zone down to 52 m depth.

Length in extension up to 190 mm, diameter 0.5-2 mm. Colour in life: body pink; lophophore transparent with white (occasionally yellow, green or red) pigment spots. Lophophore horseshoe-shaped with ends turned medially. Tentacles up to 190, length 1.5-2.5 mm. Nephridia with single funnel, descending and ascending branch, nephridiopore on anal papilla opening below anus. Single giant nerve fibre, on left side, 7-27 μm in diameter, very thin nerve fibre rarely present on right side. Longitudinal muscle bundles of feathery type; general formula is:

$$[24\text{-}53]\ \frac{7\text{-}19 \mid 7\text{-}18}{4\text{-}11 \mid 4\text{-}11},\ \text{mean formula is } 35 = \frac{12 \mid 11}{6 \mid 6}.$$

Sexual reproduction dioecious; females brooding embryos in single mass in lophophoral cavity through nidamental glands of type C (*i.e.* formed by fusion of inner row of lophophore tentacles); males with large, glandular lophophoral organs. Asexual reproduction by transverse fission.

Larva: *Actinotrocha sabatieri* Roule, 1896.

Remarks

In South Australia during the benthic survey of Spencer Gulf, *P. psammophila* was recorded at seven stations, occurring with *Phoronopsis albomaculata* only at St. 33 (Fig. 2; Table 2), at which site its density reached about 40 individuals.m^{-2}. In Cabbage Tree Basin, NSW (Rainer & Fitzhardinge 1981) (Fig. 1), *P. psammophila* was found in three locations where the salinity varies between 27.8 and 36.2‰ and the annual temperature range between 10.7 and 26.4°C: in stable sand flat at 0.3 m (but presence appears rather uncommon in shallower sites in this basin); in a silty sand with patches of *Posidonia australis* at 2 m depth; and in silty sand with surface detritus at 5 m depth. This last location has a much lower concentration of dissolved oxygen, which confirms the ability of this species to live in waters containing small amounts of oxygen (Emig 1982b). The associated fauna is common in many estuaries along the south-east Australian coast.

In New Zealand, *Phoronis psammophila* has been collected in the northern part of North Island, in Howick (Auckland Harbour) in a *Zostera* patch in sandy mud and sporadically in Whangateau Harbor (D. P. Gordon, personal communication); in Ranganna Bay in fine sand at 21 m (34°50′38″S, 173°14′60″E); in Doubtless Bay in fine sand at 17 m (34°56′21″S, 173°24′43″E) and in sandy mud at 52 m (34°56′21″S, 173°24′43″E). The last location is the deepest record for *P. psammophila*. In the last two locations the specimens, collected with a Smith-McIntyre grab, are sparsely distributed (2-3 individuals per haul).

In the Nouméa lagoon, New Caledonia (Fig. 3; Table 3), *P. psammophila* occurs at low density in fine to coarse sands, generally covered with a rich epibiosis, and in seagrass beds of *Halodule minervis* with *Halimeda* (St.65, 119A, 119B); its density varied from 3 to 100 individuals.m^{-2}. This species occurred

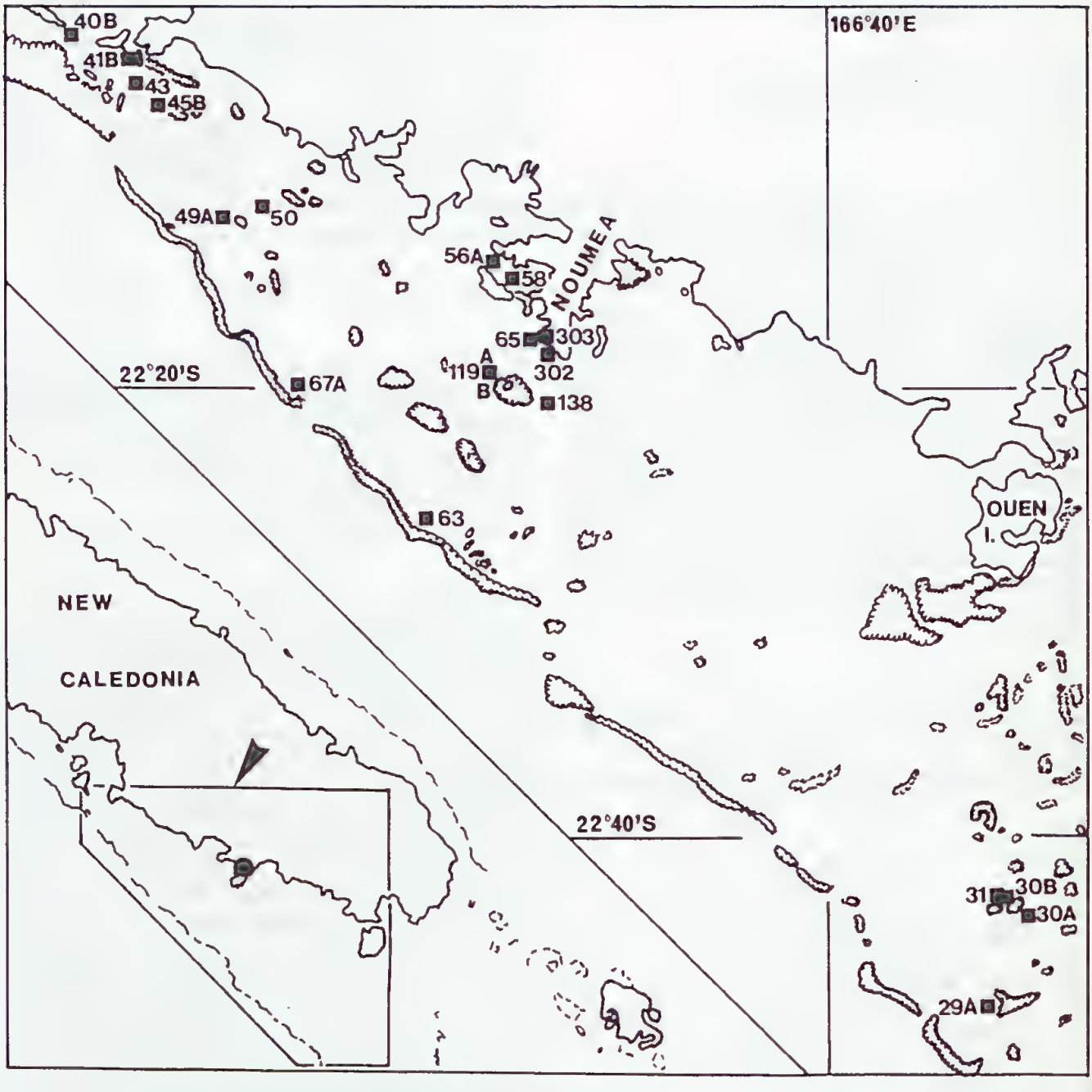

FIGURE 3. Map of the stations at which phoronid species have been recorded in the Nouméa lagoon (numbers correspond to station numbers of Table 3).

generally with one or two other phoronid species, *e.g. Phoronis muelleri* Selys-Longchamps, *Phoronopsis albomaculata* and/or *Phoronopsis harmeri* Pixell (Table 3). In the Anse Vata (0-2 m; St. 302) and in the Baie des Citrons (2-5m; St.303, 65), *Phoronis psammophila* occurs with *Phoronopsis harmeri* at very shallow depth.

The various populations of *Phoronis psammophila* cannot be characterized by the formulae of their longitudinal muscles (Table 4), for large variations occur within the populations, and within and between geographical areas. No relationship could be established with environmental factors.

Phoronopsis albomaculata Gilchrist

Phoronopsis albomaculata Gilchrist, 1907: 152.

Distribution in the Pacific Ocean (Fig. 1).

Russia: 2. Peter-the-Great Bay, Poss'yet Bay (Emig & Golikov 1990). *Australia:* 10. Moreton Bay, Queensland (Emig 1977; Emig *et al.* 1977); 15. Port Phillip Bay, Western Port, Victoria (Emig *et al.* 1977); 16. Spencer Gulf, S. Aust. (coll. South Australian Museum; Fig. 2). *New Caledonia*: 11. Nouméa lagoon (coll. C. C. Emig, B. A. Thomassin; Fig. 3). *New Zealand*: 14. Otago, Portobello (Rainer 1981; coll. Portobello Marine Laboratory). *Panama*: 20. (Emig 1982a).

TABLE 2. Records of *Phoronis psammophila* and *Phoronopsis albomaculata* in Spencer Gulf (see map in Fig. 2) and of *Phoronis australis* in Australian waters. Surface per grab haul is 0.1 m^2. SAM = South Australian Museum.

St.	Depth (in m)	Sand	Number of individuals per grab haul Nov. 85	Feb. 86	Aug. 86	Feb. 87	Sept. 87	Reg. No. SAM.L. . .
Phoronis psammophila								
18	10	fine					3	513
22	10	fine			1			503
23	12	fine			2		2 1	504, 514, 515
28	12	medium					1	516
29	13	fine					1	505
31	8	coarse					1	517
Phoronopsis albomaculata								
20	22	coarse					1	526
27	7	fine		6 7 6	1 2 1		2 4 4 11	521-525 527-530
Phoronis psammophila and *[Phoronopsis albomaculata]*								
33	5	very fine	2	2 1	1 4 1	1	1 3+[2]	506-512 518-520 [531]

Phoronis australis:
– Waterman Bay (W Australia, 31°51′S, 115°45′E), Coll. Noel Morrissy, Reg. No. SAM.TL 7294
– Southport (Queensland), Reg. No. SAM.TL 6605

TABLE 3. Records of Phoronida in the Nouméa lagoon (collected by B. A. Thomassin and C. C. Emig) (see map in Fig. 3); the data in italics represent individuals.m^{-2}. In St.119A, 119B, and 138, the percentage of organic carbon is 0.3-0.35 FF = fine fraction of the sediment (<63 μm). SAM = South Australian Museum.

St.	Depth (in m)	*Phoronis* *mueller*	*psammophila*	*Phoronopis* *albomaculata*	*harmeri*	Sand	%FF	Reg. No. SAM.L. . .
29A	24	*5*	*5*					
30A	12			2				
30B	6		1					643
31	16		2					
40B	17				1	fine muddy		
41B	6	*3*		*9*	*3*			652 649 641
43	21	8	1			coarse	11	
45B	13			1				
49A	10		2	3		coarse	3	650 644
50	26	1	3		5	coarse	4	653 645 642
56A	15	*20*				fine muddy		
58	10	2				sandy mud		
63	11		*3*	*3*		fine	4	
65	5		2	6		coarse	5	651 646
67A	14	*5*				coarse fine		
119A	6		*40*		*50*	coarse		654 647
119B	6		*40*		*40*	coarse	6	655 648
138	24	*10*				fine muddy		
302	0.5–2		*50*		*300*	coarse		
303	2–5		*100*		*100*	fine		

TABLE 4. Longitudinal muscle formulae of *Phoronis psammophila* recorded in the Pacific Ocean and southern Australian waters (see Fig. 1 for locations). N = number of specimens examined.

Locality	N	Mean	General Formula	
13. New Zealand	6	$26 = \frac{9 \mid 9}{4 \mid 4}$	$\frac{9-10 \mid 8-9}{4-5 \mid 4-5}$	[25–28]
16. Spencer Gulf	8	$33 = \frac{11 \mid 10}{6 \mid 6}$	$\frac{10-14 \mid 9-12}{5-6 \mid 5-8}$	[29–39]
20. Panama	33	$37 = \frac{13 \mid 12}{6 \mid 6}$	$\frac{9-16 \mid 9-14}{5-9 \mid 5-9}$	[28–48]
9. Solomon	4	$37 = \frac{11 \mid 12}{7 \mid 7}$	$\frac{10-12 \mid 11-12}{7-8 \mid 6-9}$	[35–38]
5. China	10	$38 = \frac{11 \mid 12}{8 \mid 7}$	$\frac{9-14 \mid 10-14}{7-9 \mid 6-9}$	[33–46]
2. Russia	11	$39 = \frac{12 \mid 12}{8 \mid 7}$	$\frac{10-14 \mid 10-15}{6-10 \mid 6-9}$	[32–46]
11. New Caledonia	22	$40 = \frac{13 \mid 12}{8 \mid 7}$	$\frac{9-17 \mid 8-18}{5-11 \mid 5-10}$	[29–53]
15. Melbourne	36	$47 = \frac{15 \mid 15}{9 \mid 8}$	$\frac{11-19 \mid 11-17}{6-11 \mid 6-11}$	[34–53]
19. Hawaii	2	$\frac{10 \mid 10}{7 \mid 7}$ = 34 and	$\frac{11 \mid 10}{6 \mid 6}$ = 33	
Total for species	3 137	$35 = \frac{12 \mid 11}{6 \mid 6}$	$\frac{7-19 \mid 7-18}{4-11 \mid 4-11}$	[24–53]

Diagnosis

Embedded vertically in soft sediments, generally coarse sands. From 0 to 55 m depth.

Length in extension up to 150 mm, diameter 0.5-2 mm. Colour in life: body pink; lophophore transparent with pigment spots. Lophophore horseshoe-shaped with ends turned medially, up to one coil. Tentacles up to 160, length 2-3 mm. Nephridia with single funnel, descending and ascending branch, nephridiopore on anal papilla opening below anus on collar fold within invagination. Giant nerve fibre paired, left fibre only present below nephridial level on left side (15-35 μm in diameter). Longitudinal muscle bundles of feathery type; general formula is:

[44-102] $\frac{14\text{-}33 \mid 13\text{-}34}{7\text{-}20 \mid 6\text{-}20}$, mean formula is

$68 = \frac{22 \mid 21}{13 \mid 12}$.

Sexual reproduction dioecious; females probably having brooding pattern; males with large glandular lophophoral organs. Asexual reproduction by transverse fission.

Larva: unknown.

Remarks

In South Australia, during the benthic survey of Spencer Gulf, *Phoronopsis albomaculata* was recorded at three stations, occurring with *Phoronis psammophila* at St.33 (Fig. 2; Table 2). Its density reached about 70 individuals.m^{-2} at St.27; a similar density (up to 75 individuals.m^{-2}) has been cited near Tuléar, Madagascar, by Thomassin & Emig (1983).

During a survey of the Nouméa lagoon (New Caledonia) (Fig. 3; Table 3), *Phoronopsis*

TABLE 5. Longitudinal muscle formulae of *Phoronis albomaculata* recorded in the Pacific Ocean and southern Australian waters (see Fig. 1 for locations). N = number of specimens examined.

Locality	N	Mean		General Formula	
20. Panama	22	54	$\frac{18 \mid 18}{9 \mid 9}$	$\frac{16-21 \mid 15-23}{8-12 \mid 8-12}$	[47– 67]
14. Portobello	4	56	$\frac{18 \mid 19}{10 \mid 9}$	$\frac{18-19 \mid 18-19}{8-13 \mid 8-10}$	[54– 59]
16. Spencer Gulf	34	56	$\frac{19 \mid 18}{10 \mid 9}$	$\frac{15-22 \mid 13-21}{8-12 \mid 7-11}$	[44– 63]
15. Melbourne	14	59	$\frac{19 \mid 20}{10 \mid 10}$	$\frac{14-23 \mid 15-24}{7-13 \mid 7-13}$	[46– 68]
11. New Caledonia	10	65	$\frac{21 \mid 19}{13 \mid 12}$	$\frac{17-27 \mid 17-21}{10-15 \mid 9-13}$	[53– 76]
2. Russia	31	67	$\frac{21 \mid 21}{13 \mid 12}$	$\frac{14-27 \mid 16-28}{9-17 \mid 6-17}$	[48– 80]
10. Moreton Bay	20	80	$\frac{26 \mid 24}{16 \mid 14}$	$\frac{19-33 \mid 19-33}{12-20 \mid 12-16}$	[62–102]
Total for species	240	68	$\frac{22 \mid 21}{13 \mid 12}$	$\frac{14-33 \mid 13-34}{7-20 \mid 6-20}$	[44–102]

albomaculata was collected by B. A. Thomassin at several stations characterized by coarse sand and fine sand at a low density of 3-9 individuals.m^{-2}.

In Otago (New Zealand) (Fig. 1), the species cited as *Phoronopsis* sp.1 by Rainer (1981: St.B10) has been identified by us as *Phoronopsis albomaculata* (material deposited in the Portobello Marine Laboratory): this species occurs at 4 m depth with a mean abundance of 9.7, in a sandy bottom (fraction 2-3 φ = 65.5%) with a large amount of coarse material and 14% organic detritus, under the influence of tidal currents. This record is from one of the coldest coastal locations in New Zealand, with water temperatures of 5-7°C in winter.

In the Russian Far East (Fig. 1) where the locations are under the influence of subtropical waters, *Phoronopsis albomaculata* has been recorded between 8 and 45 m depth with a density 8-20 individuals.m^{-2}, but up to 312 individuals.m^{-2} at 25 m in Poss'yet Bay (Emig & Golikov 1990).

As in *Phoronis psammophila*, no relationship could be established between geographical populations of *Phoronopsis albomaculata* on the basis of their muscle formulae (Table 5).

Conclusions

Phoronis psammophila is a cosmopolitan species and *Phoronopsis albomaculata*, previously considered as a tropical species, appears now as a tropical-temperate species according to its life conditions in New Zealand. The latter occurs in similar types of sandy bottoms to *Phoronis psammophila*, but in general in those with a higher amount of the coarse fraction under the influence of stronger near-bottom currents; *P. psammophila* has a higher density in well-sorted fine sands (Thomassin & Emig 1983). Such factors should explain the distribution of both species in Spencer Gulf and in the Nouméa lagoon and their co-occurrence in some locations.

The present data provide confirmation that, in Phoronida, low densities occur in tropical and subtropical waters (Emig 1982b; Thomassin & Emig 1983) in contrast to the higher densities which are cited at higher latitudes. For example, *P. psammophila*: 18000 individuals.m^{-2} in Marseille (South of France; Emig 1982b) and *Phoronopsis albomaculata*: 325 individuals per m^{-2} in the Poss'yet Bay (Russia Far East).

The taxonomic characters of *Phoronis australis*, *P. psammophila* and *Phoronopsis albomaculata* show strong similarities over the whole Pacific area, except for the muscle formulae, which vary widely within and between geographical locations.

Acknowledgments

We thank Ms Ene-mai Oks, leader of the South Australian Department of Fisheries benthic survey of Upper Spencer Gulf (1985-1987) for depositing the survey's collections in the South Australian Museum, Dr J. B. Jillett, Portobello Marine Laboratory and Dennis P. Gordon, DSIR, Marine and Freshwater Science, Wellington, for loans of the New Zealand material of *Phoronis psammophila* and *Phoronopsis albomaculata*, and Sebastian Rainer and S. J. Edmonds for comments as referees.

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GARAWA METHODS OF GAME HUNTING, PREPARATION AND COOKING

MICHAEL PICKERING

PICKERING, M. 1992. Garawa methods of game hunting, preparation and cooking. *Rec. S. Aust. Mus.* **26**(1): 9–23.

This paper describes the traditional methods of hunting, fishing, preparation, and cooking of major food animals as practised by the western Garawa people of the inland Gulf of Carpentaria, Northern Australia. The data supports an hypothesis that similar strategies for game exploitation existed across differing Australian environments and may also be reflected within the archaeological record.

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This paper is part of an exercise in salvage ethnography, the collection of data from a society which no longer practises the activities described. It is derived from information collected as part of an investigation into western Garawa traditional land use and site location patterns for the purpose of developing land use models applicable to archaeology.

The western Garawa represent a hunter-gatherer population adapted to the exploitation of a transitional sub-humid to semi-arid environment (Fig.1). Little information relevant to land use, site patterning, and related economic activities is available for such environments.

The aim has been to avoid the analytical manipulation of the data as far as possible, in favour of providing a usable ethnography. Garawa hunting strategies and preparation methods fall into three broad classes, depending primarily on animal size and general habitat. These are defined here as 'large game', 'small game' and 'aquatic game' strategies. Within each strategy there are both general and specialised methods.

Part of the author's research into Garawa land use and site patterning has involved the comparative analysis of changes in land use patterns between environmental zones. The Garawa information, as an example of economic use of a transitional environment, provides a link between the arid and tropical environments. Preliminary analysis of Garawa land use patterns and comparison with patterns from arid and humid environments suggests that highly predictable relationships exist between land use patterns and the environments in which they operate. Further, the progressive and gradual shift between environments appears to be accompanied by similar, and predictable, shifts in regional land use patterning. Results to date suggest that it may be possible to reconstruct regional patterns of prehistoric land use on the basis of environmental reconstruction and ethnographically derived models.

Garawa hunting and gathering practices reflect elements of both tropical humid to sub-humid and semi-arid to arid land use patterns. Without the mediating influence of the Garawa information the emphasis will always tend to be on the differences between these two environmental extremes. The Garawa land use data will allow for better comparative studies. Similarly the game hunting and preparation methods presented here demonstrate some degree of continuity between methods applied in both northern and southern environments (see Isaacs 1987).

The value of the Garawa data, therefore, lies in its application in comparative studies, where it not only demonstrates differences, but also similarities, between different environments. This allows for the better development of models of game processing relevant to the interpretation of the archaeological record.

METHODOLOGY

Information was collected through interviews with senior Garawa, supplemented by observation where possible. The reliance on interviews determines the 'salvage' nature of this ethnography. The practices described are rarely undertaken today.

The two major methodological problems associated with reconstruction of past practices through oral history rather than observation are those of informant reliability and information quality. The problem of informant reliability, where it is difficult to confirm whether an account accurately reflects common practice, is largely overcome through comparing consistencies in different accounts of the same practice. The methods presented here are those most consistently provided and agreed upon by informants.

The problem of information quality is that it is difficult to obtain more than a very generalised description of past practices. Where observation by researchers is possible, consistencies, anomalies and peculiarities are more easily defined and allow for a more detailed account (*e.g.* Meehan 1982, Baker 1988, Bradley 1991). Opportunities for such detailed

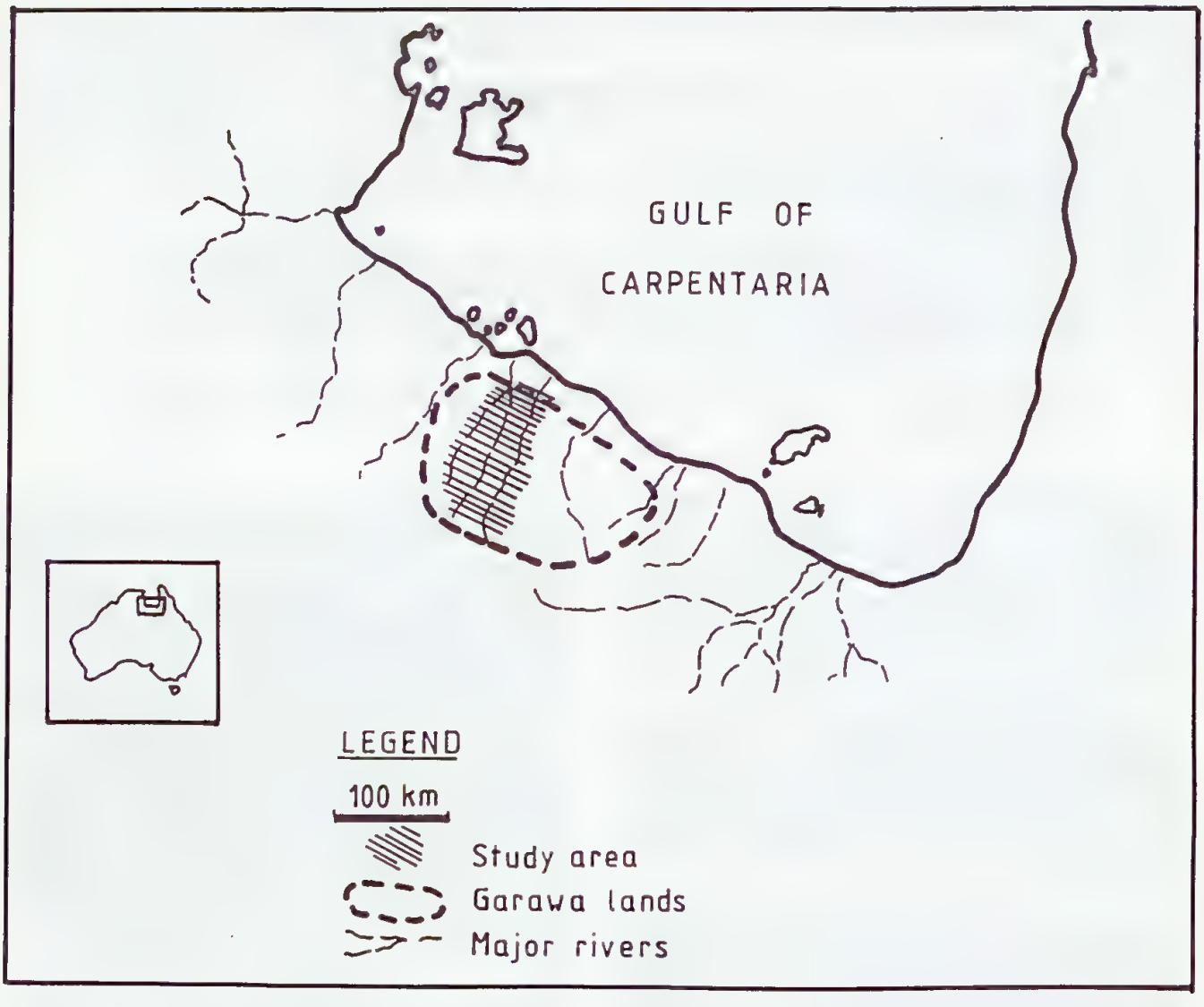

FIGURE 1. Location of Garawa country and study area.

observation are, however, decreasing. Where observation is not possible and where the account is considerably removed in time and space from the action, there is an inherent tendency towards generalisation. Generality in these ethnographic accounts should not be dismissed, when the only alternative may be no information at all. Moreover, a tendency towards generality can have its benefits, as Thomas has observed (1976: 73):

> Much of the so-called popular anthropology (the far-away-places-with-strange–sounding-names school) emphasizes the *range* of the human condition, often with a profound neglect of *central tendencies.*

The accounts provided here, although generalised, go some way towards contributing to the definition of some of these 'central tendencies'.

Animals are referred to in the text by their common names. This reflects the nature of the information, where exact identification of animals was usually not possible. Table 2 provides a summary listing of common and species names of major game animals.

Common names are preferred to species names in the text of this paper. Species names are often used indiscriminately by ethnographers, with the result that undue emphasis is placed on distinguishing specific animals rather than on the methods used to exploit them. The resulting inference is that a technique represents a specific response to a particular species, and may not also be found in different environments where that species may be absent. This paper suggests that in many cases the same methods can be applied to a variety of species of a particular genus from different environments.

The question of generating reliable analogies applicable over space and time is central to the 'land use' study from which this paper is derived. It is relatively rare for the considerable data on the economic, technological, and social practices of Australian hunter-gatherers to be used by researchers outside Australia, using ethno-archaeological models. This may be a result of the belief that distance lessens the reliability of an analogy, though researchers have often seen little difficulty in comparing ethnographic

and archaeological societies between the Old and the New Worlds (*e.g.* Binford 1983; Villa *et al.* 1986; Pickering 1989). The reluctance to include Australian material in comparative hunter-gatherer studies has also been aggravated by an over-emphasis on the unusual aspects of Australian flora and fauna. It may, for example, be argued that methods for hunting emu and kangaroo have little application to the interpretation of the archaeology of deer hunters of Europe or America. But if emus and kangaroos are approached in the context of 'large game grazing animals', rather than as 'flightless bird and leaping marsupial', the range of possible strategies for the hunting of 'large game grazing animals' is expanded. Similar concerns have been expressed by Clarke (1978: 109-110).

The Garawa And Their Environment

The Garawa

The Garawa occupy the transitional zone between the northern sub-humid to humid tropics and the southern central semi-arid to arid inland (Fig. 2). There is little information on hunter-gatherer land use or economics within this environmental zone, most studies focusing on arid desert and humid tropical environments.

Garawa social and religious phenomena are not discussed here. More specific information on these issues is provided by Avery & Mclaughlin (1977), the Aboriginal Land Commissioner (1985, 1990), and Trigger (1982, 1989). In summary, the Garawa largely conform to general principles of social and religious organization and land tenure common to northern Australian Aboriginal groups (see Maddock 1972).

Environment

Garawa homelands lie in the southern Gulf of Carpentaria between latitudes 20 degrees and 14 degrees south. The study area contains three major physiographic divisions: the northern Coastal Plains (30% of study area), characterised by lowland plains rising to undulating country; the central Gulf Fall (50% of study area), characterised by low hills and undulating country and the southern Bukalara/Barkly Plateau (20% of study area), characterised by escarpments, plateaux, and upland plains (after Aldrick & Wilson 1990).

Garawa occupation of the region centred on the major north-south running river and stream systems of the Gulf Fall, with seasonal excursions into the hills of the Bukalara/Barkly Plateau, and onto the plains of the Gulf Fall.

The heart of Garawa country lies on the notional division between the sub-humid and semi-arid climatic zones. Climate is characterised by dry warm winters (the dry) and hot wet summers (the wet). The wet summers are shorter than for the more northern humid and sub-humid climatic zones with a progressive decrease in rainfall from north to south.

The vegetative pattern of the region shows a decrease in the eucalypt-dominant tree canopy from woodland in the north to low open woodland in the south. The northern Coastal Plain consists of low to medium eucalypt woodland with intermittent low to medium melaleuca woodlands and tussock grass understorey. Foliage cover in the tree stratum is 10 to 30%. The Gulf Fall consists of low open eucalypt woodland with tussock grass and hummock grass understorey. Foliage cover in the tree stratum is usually less than 10%. The

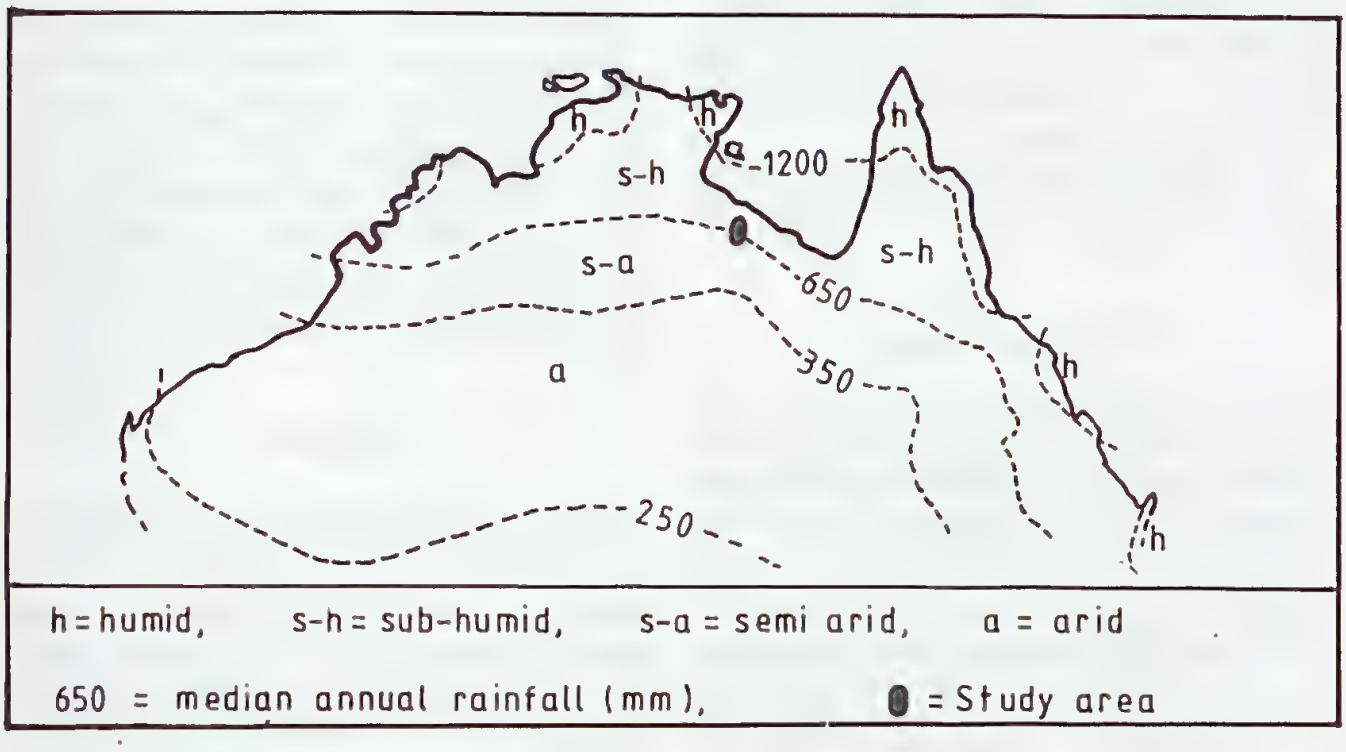

FIGURE 2. Climatic zones (after Gentilli 1986: 30).

Bukalara/Barkly Plateau consists of low eucalypt woodland with sparse tussock and herbaceous grasses. Foliage cover in the tree stratum is less than 10%. All three physiographic divisions are transected by major fluvial corridors which support localised corridors of diverse woodland and open woodland communities (after Nix & Kalma 1972; Australian Surveying and Land Information Group 1989; Gentilli 1986; Aldrick & Wilson 1990).

Land Use

Garawa land use followed the seasonal pattern. This saw an annual cycle of four major seasons: the storm time and rain time of the wet summer months and the cool time and hot time of the drier winter months. The late wet season saw a dispersal of the population from the major core areas along the river systems of the Gulf Fall into the adjacent plains and hills, now made accessible by temporary waters and seasonal efflorescence of resources. After the summer rains ceased, the progressive loss of peripheral temporary waters and resources saw a corresponding contraction of the population, through the semi-permanent waters of the major streams and lagoons, to the permanent waters of the rivers. By the late hot season the population was concentrated along the rivers where it remained through the hot, storm and early wet seasons.

This pattern of seasonal movement occurred over a relatively small area. The average range radius of the Garawa land-using group was 15 kilometres, usually centred on a major permanent water source. Late wet season camps, usually in the caves of the hills and plains, and cool season camps, usually on the semi-permanent waters of the river pools and lagoons, often fell within this 15 kilometre radius. People were rarely more than one day's walk from the richer 'core' territory of the major river channels.

This cycle of medium range movement reflected the seasonal distribution, abundance, and quality of food and water resources.

The Ground Oven

The ground oven was the most common method of cooking quantities of meat and vegetables. The author observed a number of ground ovens in use and given its role in Garawa food preparation, it is appropriate to describe its construction and operation.

The explorer Ludwig Leichhardt passed through the Gulf region in 1847 and noted:

> The fire places of the natives were here arranged in a straight line, and sheltered from the cold wind by dry branches: they were circular, the circumference was slightly raised, and the centre depressed and filled with pebbles, which the natives heat to cook their victuals.
> (Leichhardt 1847: 382)

The manufacture of a ground oven consisted of digging a pit large enough to accommodate the quantity of food to be cooked. The smallest ovens were little more than a shallow scrape in the sand – slightly less than a metre across and fifteen centimetres deep – and were used to cook several fish, fruit bat, or a lizard. The pits of larger ovens measured two metres across by 80 cms deep and could accommodate two or three kangaroos.

A large fire was lit in or adjacent to the pit. The animal was briefly thrown on it to singe off its fur, feathers or quills. The animal was quickly removed and the skin scraped and brushed clean. Larger animals were usually then gutted. When the fire had died down to hot coals, about two-thirds of these were placed in the pit. The carcass was laid in the coals and the remaining coals arranged on and around it. If stones were available these were heated in the fire and stuffed into the body cavity (in the case of larger game) or were placed around the animal.

The animal and its blanket of coals were then covered with sheets of paperbark or other vegetation to hand. This provided both a heat and steam seal and kept the meat clean. Soil was then packed over the paperbark. The oven was considered to be well sealed if no steam or smoke was seen to escape. The oven was then left alone for varying periods, from one hour for limited amounts of small game and fish, to overnight (eight hours) for larger game or greater bulk, though the latter time period often depended upon people's enthusiasm for opening the oven in the middle of the night. Three to four hours appears to have been the maximum cooking period for large game.

The oven and stones would be re-used if a site was continually occupied or re-occupied. Once game was cooked little artefactual assistance was necessary to butcher any animal. Cooked animals were easily dismembered and apportioned by hand, severing at joints and along muscle faces. Suitable long bones were occasionally cracked to extract the marrow. This produced long and irregular splinters. The consumption of marrow was not a regular occurrence and depended upon individual preference at the time.

Bone Burning

Bone and shell remains were commonly thrown into the fireplace and 'burnt'. The western Garawa informants describe this as mandatory and necessary to ensure a continued plentiful supply of fat animals. Robins & Trigger (1990: 45-48) describe slightly differing patterns of bone burning practice amongst the eastern Garawa and their Waanyi and Ganggalida neighbours.

The Garawa definition of 'burning bone' does not necessarily guarantee its destruction. Bones are 'burnt' by throwing them into the fireplace which was rarely hot enough to completely destroy or reduce the bone. Bones were often only slightly charred or calcined. Calcined bones easily broke into small fragments similar to those often associated, by archaeologists, with breaking of bones for marrow extraction.

Animals And Strategies

Game hunting and preparation methods are considered here to fall into three major strategy classes, defined primarily according to animal size and general habitat. 'Large game' strategies targeted the highly mobile animals found in the fluvial corridors and plains: kangaroos, wallabies, emus, and bush turkeys.

TABLE 1. Seasonal frequency of major food animals.

	WET				COOL			HOT		STORM		WET
	J	F	M	A	M	J	J	A	S	O	N	D
ANIMAL												
Mammals												
Macropods	OOO	OOO	OOO	OOO	OOO	OOO	OOO	OOO	OOO	OOO	OOO	OOO
Possum	ooo	...	...	...	...	...	...	...	...	...	.oo	ooo
Bandicoot	ooo	o..	...	...	...	...	...	...	...	...	...	.oo
Echidna	...	...	...	...	...	...	...	...	...	...	.oo	ooo
Dingo	...	...	...	...	...	...	...	...	...	...	...	...
Fruit bat										OOO	OOO	OO
Reptiles												
Goanna	OOO	OOo	ooo	ooo	ooo	ooo	ooo	ooo	ooo	ooo	oOO	OOO
Blue-tongued lizard	OOO	Ooo	ooo	ooo	ooo	ooo	ooo	ooo	ooo	ooo	ooo	OOO
Frilled lizard	ooo	ooo	o..	...	...	...	...	...	...	ooo	ooo	ooo
Black-headed python	...	...	.oo	ooo	ooo	ooo	oo.	...	...	...	...	...
Tortoise (longneck)	...	...	...	...	...	oOO	OOO	OOO	OOO	OOO	Ooo	...
Tortoise (shortneck)	...	...	...	...	...	...	...	oOO	OOO	OOO	OOo	...
Water snake	...	...	...	...	...	...	...	...	...	...	...	...
Crocodile	...	...	...	...	...	...	...	...	...	...	...	...
Birds												
Emu	OOO	OOO	Ooo	ooo	ooo	ooo	ooo	ooo	ooo	ooo	ooO	OOO
Plains bustard	...	...	...	...	...	...	...	...	...	...	...	...
Bird eggs		..	...									
Birds (spp.)*							...	...	...			
Fish												
Fish (all spp.)	...	...	...	...	...	...	.oo	ooO	OOO	OOO	Ooo	...
Freshwater crayfish	...	...	...	...	...	...	ooo	ooo	ooo	oo.	...	...
Freshwater mussel	...	...	...	...	...	...	ooo	ooo	ooo	o..	...	...
Insects												
Sugarbag	ooo	ooo	ooo	ooo	ooo	ooo	ooo	OOO	OOO	OOO	OOO	ooo
	J	F	M	A	M	J	J	A	S	O	N	D
	WET			COOL				HOT		STORM		WET

..... = Low frequency
ooooo = Medium frequency
OOOOO = High frequency
* = north of study area

'Small game' strategies targeted the localised animals of the lagoons, plains and hills: snake-necked tortoises, lizards, possum, echidna, fruit bats, crocodile, etc. 'Aquatic game' strategies targeted animals of the semi-permanent to permanent waters: fish, short-necked tortoises, crayfish, crocodiles, and mussels. Table 1 provides a summary of the seasonal distribution and relative abundance of animal resources referred to in this paper.

Classification on the basis of size does not reflect the overall contribution which each class of game made to Garawa diet. A large game hunt could proceed in the full knowledge that an alternative, more productive, and more accessible small game meat source was available. A successful large game hunt might also produce less meat than a moderately successful small game hunt or fishing trip.

While most native animals are edible not all were consumed. This was a result of numerous factors, including flavour, ease and economy of capture and general palatability, the latter being more a subjective, rather than a nutritional, determinant. The decision as to target was based not only upon the availability of the resources and the economic efficiency of pursuing it, but also upon the hunter's sex, personal preference, enjoyment and ego. The result is that a simple listing of potential food species, as is common in reconstructions based largely on reference to basic floral and faunal data, would not accurately reflect the list of actual food species which dominated the diet.

Table 2 provides a summary listing of the major species utilised. This table is compiled on the basis of informants' descriptions of animals rather than on carcass identification. It is considered a minimum listing of actual food species and no doubt a number of other species were also utilised. A large number of potential food species is available in Arnol *et al.* (1983) which lists animal species for the western neighbouring McArthur River Catchment.

Large Game Strategies

The general strategy

There was a general strategy applied to all large game animals. This was the simple stalking of game sighted while hunting opportunistically. Prior to a stalking hunt the hunter would smear himself with white ochre. This concealed the smell of the hunter and provided a degree of camouflage through breaking up the hunter's outline. Occasionally the camouflage would be supplemented by holding two small leafy branches (70–100 cms) butt to butt, effectively forming an 'hourglass' of leaves which assisted in concealing the hunter. The hunter would then carefully stalk to within effective spear range of the target, usually within 10 metres. This method was most commonly used with large game animals encountered unpredictably in the open woodland country of the plains and low hills.

The aim in large game hunting was to disable the animal to the point where capture was assured. Immediate death or disabling injury were equally acceptable. The largest, and preferred, target zone of most large game was the hips, pelvis, and lower abdomen. The result was that in a successful hunt animals were often wounded to the point of being unable to escape. In this incapacitated state the animal might be left alive until required. This was rarely longer than a few hours but might extend overnight. In a warm to hot climate this considerably prolonged the freshness of the meat.

The hunting of large game animals was usually the preserve of males although the capture of a wounded animal could involve women and children. Until rifles became commonly used, the hunting tool kit comprised spears with wood, stone, or metal heads, spear throwers, and a stone or steel knife.

Hunters would go out singly or in company. They rarely stayed out from the base camp longer than one day, although occasionally one to three night hunting camps would be made. The hunter's family might accompany him on overnight trips, remaining at a small hunting camp while he ranged further afield during the day.

Dingoes, and later domestic dogs, which had proven useful hunters, would be used occasionally, particularly in pursuing wounded game. The dogs would quietly remain with the hunters' extra spears and equipment, which was put down when a target was sighted. When the prey was hit the hunter would call up the dogs which would scent the blood and pursue and harass the animal until the hunter could catch up.

Upon the capture of a large animal a fire would be lit to signal other hunters in the vicinity and residents of the home camp. If the hunter was some distance from the home camp the animal might be partially prepared by gutting, singeing of fur or feathers, and occasionally by complete cooking on site. If the members of the home camp were particularly hungry they would go out to meet the hunter.

Macropods

There is a variety of macropod species in all the environmental zones of the study area. These range in size from the large heavy common and antilopine wallaroos and the occasional red kangaroo through to the smaller agile wallabies (see Table 2).

By all accounts macropods were caught regularly, with reports of at least one per hunter per week being a minimum and with one to two per day being the regular capture rate for a good hunter.

The best time to hunt macropods was in the early morning or late evening when they were feeding and watering in the open, close to main water sources. During the hotter midday period they would disperse to shelter under trees and in rock shelters which effectively concealed them from hunters and allowed

them to be warned of a hunter's approach. The cool season, between March and August, was the optimum time for hunting macropods, though they were available and were hunted all year long. The wet season abundance of food and water encouraged game to disperse widely onto the plains and into the hills. By August, as the hot season commenced, the animals were forced, by dwindling food and water, to retreat to the more permanent waters where the Garawa were also focused. This concentration of numbers meant that their availability and behaviour became more predictable at this time. Apart from this general strategy of careful stalking of opportunistically sighted game, there were several other specialised techniques. One technique, used when a resting hill kangaroo (wallaroo/euro) was sighted lying in a low rock shelter, was to quietly move to a point immediately above the shelter. The hunter would then wipe a stone under his

TABLE 2. Major game animals.

Common Name	Species	Weight/Size	Reference
Mammals			
Northern nailtail wallaby	*Onychogalea unguifera*	4.5-9.0 kg	Gordon 1983a: 204
Agile wallaby	*Macropus agilus*	9.0-27.0 kg	Merchant 1983: 242
Common wallaroo/euro	*Macropus robustus*	6.25-46.5 kg	Poole 1983: 251
Antilopine wallaroo	*Macropus antilopinus*	16.0-49.0 kg	Calaby 1983a: 253
Red kangaroo	*Macropus rufus*	17.0-85.0 kg	Sharman 1983: 255
Rock ring-tail possum	*Pseudocheirus dahlii*	1.28-2.0 kg	Nelson & Kerle 1983: 132
Northern brush-tail possum	*Trichosurus arnhemensis*	1.1-2.0 kg	Kerle 1983: 149
Northern quoll	*Dasyurus hallucatus*	300-900 gm	Begg 1983: 23
Black-footed tree rat	*Mesembromys gouldii*	430-870 gm	Calaby 1983b: 383
Northern brown bandicoot	*Isoodon macrous*	0.5-3.1 kg	Gordon 1983b: 96
Echidna	*Tachyglossus aculeatus*	2.0-7.0 kg	Augee 1983: 8
Dingo	*Canis familiaris*	9.6-19.4 kg	Newsome 1983: 483
Black flying flox	*Pteropus alecto*	500-700 gm	Hall 1983: 280
Little red flying fox	*Pteropus scapulatus*	300-600 gm	Richards 1983: 277
Reptiles			
Freshwater crocodile	*Crocodylus johnstonii*	2.0 m	Cogger 1980: 2
Snake-necked tortoise	*Chelodina rugosa*	30 cm	Frith 1983: 22
Northern snapping tortoise	*Elseya dentata*	30 cm	Frith 1983: 23
Short-necked tortoise	*Elseya australis*	30 cm	Cogger 1980: 6
Gould's goanna	*Varanus gouldii*	7.0 kg	Frith 1983: 34
Mertens' water monitor	*Varanus mertensi*	1.0 m	Frith 1983: 45
Spotted tree monitor	*Varanus timorensis*	60 cm	Frith 1983: 37
Blue-tongued lizard	*Tiliqua scincoides*	30 cm	Frith 1983: 45
Frilled lizard	*Chlamydosaurus kingii*	85 cm	Frith 1983: 31
Black-headed python	*Aspidites melanocephalus*	3.0 m	Frith 1983: 47
Arafura file snake	*Acrochordus arafurae*	2.5 m	Frith 1983: 50
Little file snake	*Acrochordus granulatus*	1.0 m	Frith 1983: 50
Birds			
Emu	*Dromaius novaehollandiae*	1.5-1.8 m	Pizzey 1982: 21
Plains bustard	*Ardeotis australis*	15.0 kg	Pizzey 1982: 107
Fish			
Black bream	*Hephaestus fuliginosus*	30 cm	Arnol *et al.* 1983: 302
Salmon catfish	*Hexanematichthys* sp.	30 cm	Arnot *et al.* 1983: 302
Eel-tailed catfish	*Neosilurus* sp.	30 cm	Arnot *et al.* 1983: 302
Sleepy cod	*Oxyeleotris lineolatus*	20 cm	Arnol *et al.* 1983: 302
Barramundi	*Lates calcarifer*	50 cm	Arnol *et al.* 1983: 302
Perch	*Abassis* spp.	20 cm	Arnol *et al.* 1983: 302
Archer fish	*Toxotes chararеus*	15 cm	Arnol *et al.* 1983: 302
Freshwater crayfish	*Cherax quadricarinatus*		Arnol *et al.* 1983: 303
Freshwater mussel	*Velesunio angasi*	8 cm	Arnol *et al.* 1983: 303
Insects			
Sugarbag/Native bee	*Trigona plebia* *Trigona tetragona*		Akerman 1979: 169 & Michener 1965: 230-1

(0.0 cm) = average size based on observations.

armpit, wetting it with sweat and then throw the stone upwind of the animal. The noise and scent would alert the animal which would try to escape downwind. Once out of concealment the animals often pause briefly to check the source of alarm. This usually occurred within effective spear range (within 10 metres).

Another technique, used in the wet season around the replenished swamps and lagoons of the plains, was for hunters and dogs to drive the macropods into boggy or swampy ground where they could be clubbed. They could also be driven towards hunters. This appears to have been an opportunistic rather than a premeditated strategy. A group on a hunting or foraging round might sight macropods but be in a poor position for pursuit (*e.g.* upwind, no spears, etc). The group might attempt to drive the animals in the direction of known hunting parties. Occasionally fires would be lit to assist the drive.

Once killed the macropod was prepared for cooking. The fur was singed, scraped off, and the animal gutted, with the exception of the heart and lungs which did not contaminate or flavour the meat. The stomach and part of the intestine were cleaned and then stuffed with the intestinal fat. This package was placed inside the body cavity. The front legs would be tied together with bark. The hind legs would be snapped forward at the joint of the femur and tibia. This allowed the legs to be laid flat along the body. The tail would be partially severed at the base to allow it to be bent along the body. The tail and hind legs would then be secured by passing them through the tied forelegs. The animal was then cooked in a ground oven.

Emu

As well as the stalking strategy described there were several specialised strategies for hunting emu. These relied for their success on the predictability of the birds' behaviour. The best time for emu, the period when their presence and behaviour was most predictable and when they would be in the best condition, was in the late wet season (February – March) and early cool season (March – April). This was the time when the trees fruited along the temporary seasonal watercourses, providing the emus' favourite food.

An extension of the general strategy involved waiting in concealed hides at water sources where fresh tracks had been observed, spearing the emu upon its return to water.

During the wet season the most common method, in the course of general foraging, was to look for fresh tracks at the base of fruit trees. The hunters would return to these trees the next morning and would make a simple platform, or 'nest', in the branches, ensuring that there was sufficient room to use the spear and spear-thrower. When the emu returned to eat the freshly fallen fruits the hunter would spear it.

The curiosity of the emu was also exploited. Having sighted an emu the hunter would conceal himself and wave a cloth or object, occasionally making an unusual sound. The emu would approach the lure to within spear range. Often two men would co-operate, one providing the lure and the other standing ready with the spear. A further modification of this technique had the hunter lying down in the grass and waving a foot in the air. Again the emu would be attracted to within effective spear range.

Upon capture the emu would be plucked and the remaining feathers singed off. It was then gutted. The intestinal fat would be stuffed into the cleaned crop which would then be placed in the body cavity prior to cooking. The animal would then be cooked in a ground oven.

Emu eggs were eaten when found. Due to their strong, heavy shells they could be simply roasted in an earth oven without breaking.

Certain restrictions on the consumption of emu fat applied to women and children.

Australian plains bustard/bush turkey

The Australian bustards, or bush turkeys, were encountered opportunistically on hunting trips in the open woodlands. They were available throughout the year, though encounters were more likely in the wet season when they fed on the fruiting trees along the temporary watercourses. Bustards were a favoured food but rarely caught, largely due to the haphazard nature in which they were encountered combined with their alertness in avoiding hunters.

Once a bustard was sighted the general strategy of careful stalking was most commonly used. The bustards also returned to the same waters each day. A hunter, having observed fresh tracks near a water source, would lie in wait for the bustard's return, or would try there again in the early morning or late afternoon.

A captured bustard would be plucked, singed, gutted, and cooked in a ground oven.

Summary

Large game, relatively common throughout the year, was most frequently captured using a general stalking strategy. This was employed as the exact location of large game was unpredictable, with occasional exceptions. Under certain environmentally determined circumstances, where the likelihood of game encounter was increased, alternative and more specialised techniques could be applied. Animals were prepared and cooked in a standard way. Major carcass dismemberment usually occurred after cooking and was easily accomplished with little technological assistance.

Small Game Strategies

Small game strategies targeted a range of mainly terrestrial fauna. These animals provided the bulk of the Garawa daily meat diet. Small game animals were

usually highly predictable in terms of their location, seasonal availability, meat quality, and likely minimum capture numbers.

Although many of the small game species described here could be specifically targeted, most were captured opportunistically, in the course of general foraging. A simple example would see a hunter returning with a mixed bag of lizards, tortoises and 'sugarbag' honey.

Small game could be collected or hunted by males and females working singly or in company. A hunter after large game would nonetheless usually pursue any suitable small game he happened across.

Lizards and snakes

Lizards were a major food source with three main genera exploited, the monitor goannas, the blue-tongued lizards, and the frilled (or blanket) lizard.

The usual preliminary to lizard hunting was the burning-off of grass and leaf litter. The reason consistently given for burning grass was that it cleared the ground to facilitate the hunting of lizards. Fires were lit at any time of the year when the grass and litter looked flammable. Patches of less than a hectare were quite acceptable for this purpose. Hunters or foraging parties would regularly light such fires on their travels. A day or two later they would return to the burnt area to hunt for lizards. The burning-off produces a layer of black ash in which the tracks and burrows of lizards are easily seen.

When hunting lizards, Garawa would intensively work a localised area. In one observed episode three people took one hour to cover a 300 by 200 metre area for a return of two goanna and one blue-tongued lizard. The area was known to have been heavily exploited by another group not long before this hunt.

Goanna

Goanna were hunted throughout the year though they were more common, and in better condition, in the wet season and early cool season. During the heat of the day they occupy shallow burrows, easily located on a cleared ground surface through the freshness and bright colour of the soil from the burrow overlying the black ash and by the direction of the clear tracks. Once located the burrow was checked for an exit hole. If only one hole was present it was likely that the goanna was still inside. If there was an exit hole the burrow was considered unlikely to contain a goanna but was checked for other lizards and snakes. Checking consisted of probing the soil around the burrow with a digging stick or suitable implement. When a goanna was felt the hunter would dig along the length of the burrow to the lizard's tail, which was then seized and the lizard dragged out of the hole.

When a goanna was caught it could either be killed immediately by clubbing or alternatively, and more frequently, some or all of the legs were broken to disable the animal while keeping it alive. This 'breaking' consisted of bending the joint of the legs at the junction of the femur and tibia. This is variously described as breaking the leg, breaking the 'string', and 'hobbling'. With the legs immobilized the goanna could be kept alive and fresh until required. This could be for up to a month, when collecting prior to hosting ceremonies, although several days appeared to be the maximum. In this state the goanna could be given or traded to other people or kept in reserve for gatherings.

Once killed the goanna was gutted, usually through a cut at the junction of the neck and chest. Several goanna would be cooked in a suitably-sized ground oven, but a single goanna would be cooked in the open coals of the hearth. The legs were tied to prevent their spreading in the fire, and the animal was usually cooked belly down.

Water goanna were also hunted, though not with the frequency or success of the land goannas. These were usually caught using a single pointed spear while fishing.

Blue-tongued lizards

Blue-tongued lizards occupy the vacated burrows of goannas and were caught in the same way. One informant described them as " . . . bludger along goanna camp . . . ". They were available all year. When captured the blue-tongue could either be killed immediately or kept alive until required. Their legs were rarely broken to restrain them as they were considered fairly harmless. Once killed they were prepared and cooked in the same way as goanna.

Frilled lizard

The frilled (or blanket) lizard was mainly found around trees and logs. It was relatively scarce during the cool and hot seasons, becoming increasingly common during the storm and wet seasons. They were often seen in considerable numbers in front of grass fires where they were driven by flames and smoke. They were caught by clubbing or with dogs. The frilled lizard was considered a 'cheeky' lizard, likely to bite and scratch, and when caught they were immediately killed. They were prepared and cooked in the same way as goanna and blue-tongued lizards.

Snakes

Snakes were available throughout the year although the best season for hunting was the cool time when they were fat and slow. The most popular food species were the non-venomous varieties, particularly the black-headed python. Snakes were often captured while people hunted goanna, as they occupied disused burrows. Water snakes were occasionally caught while fishing or collecting lily roots. Once killed the snake would be coiled into a bundle and tied with bark. It was then cooked in a ground oven. The guts were removed after cooking.

Echidna and possum

Garawa use of the name possum appears to refer not only to the rock ring-tail possum and the northern brush-tail possum but also to other marsupials of similar size occupying similar environmental niches, such as the northern quoll and black-footed tree rat. This discussion refers to the possum but these other species were captured by the same methods.

Although unrelated species, the echidna and possum were caught using the same strategies and at the same time. The echidna, or spiny-anteater, and the possum are found throughout the region but are most abundant in the rocky low hills of the southern half of the study area. This habitat was usually not intensively occupied by the Garawa until the middle and late wet season and early cool season. In the early cool season the Garawa would move down to the flatter fluvial corridors and adjacent plains where echidna and possum were present but more dispersed and in fewer numbers and, by the advent of the hot season, in poorer condition. Hunters on the plains also targeted a different and relatively more locally abundant range of animals such as tortoise and lizards. Thus possum and echidna, although available all year, were only major food animals in the wet and early cool seasons when specialised methods were applied to their capture. In the cool and hot seasons these animals became a less frequent, more opportunistically exploited, part of the diet.

Echidna were hunted by both day and night. During the hot daylight hours they tend to rest in crevices and ant beds, becoming more active at night. In the daytime hunters would be alert for tracks, following these to the resting animal. Once located the animal was killed, either by clubbing the head or, when well dug in, by stabbing a small hardwood stick of about 40 cms in length, between the spines, under the ribs and into the heart.

Night hunting was used for both echidna and possum and largely relied on the use of suitably trained dogs. Hunters would go to the rocky hills on moonlit nights with proven hunting dogs. These would be allowed to run free. When the dogs located prey they would make a noise. The hunter knew this indicated they had caught or bailed up some animal and would go to check and kill the capture. The echidna was clubbed or stabbed, as described. Possum were usually forced into a tree or rock crevice by the pursuing dogs. The hunter would knock them down onto the ground with a club or spear where they could be clubbed, speared, or mauled by the dogs.

Echidna were prepared by first singeing the spines in an open fire. This loosened the quills and removed the sharp tips. The quills were then 'plucked', usually by laying the animal on a hard surface and 'pinching' out clumps of spines with a stone or back of an axe. Once plucked it was gutted. The tongue was tied into a knot. The common reasons given for this practice were that: 'it stopped the good fat dripping out', 'kept the devil from getting the fat', and " . . . because it's the law . . . ". The prepared echidna was cooked in a ground oven.

Possum would be prepared by first plucking the fur, which was kept for making fur belts, and then by gutting and cooking in a ground oven.

Fruit bats

Fruit bats were only available for the short period of the storm time and early wet season. They arrive in great numbers in late October and occupy the flowering fruit trees along the permanent river pools, departing quickly when flowering is finished and the heavy rains begin in late December. For this short period they made up a large proportion of the daily meat diet.

The method for hunting fruit bats was simple and effective. Hunters would have a special hardwood club of about a metre in length. Keeping the wind in their faces, so as not to alert the bat colony resting in the branches of the trees, they would rush in vigorously swinging the clubs, knocking the bats to the ground. Once hit the bat was usually disabled by a broken or damaged limb. It was then unable to escape and was left where it fell while the hunters continued striking.

A hunter would sometimes carry two or three smaller hardwood clubs, up to 50 cms long, which were thrown into the bats on the higher branches.

The disabled fruit bats would be collected and killed, being threaded onto the clubs by the wings for transport back to the camp. The fur was singed off in the open fire and the wings broken off at the 'elbow'. If a large number of bats had been caught they would be cooked in a ground oven. If only a few had been caught they would be cooked in the coals of an open fire. The bats would be gutted after cooking. The reasons for not gutting them prior to cooking were that they would lose too much good fat and that they were too small to worry about.

Cooked fruit bats would sometimes be wrapped in a paperbark bundle for transporting. In some special locations certain restrictions on consumption of fruit bats were applied to women and children.

Snake-necked tortoises

The snake-necked tortoise is found in the billabongs, lagoons, and swamps of the plains in the northern half of the region. These waters are characteristically temporary, relying on wet season replenishment by river flooding. Through the wet season to middle cool season these sources were full and the tortoises active and difficult to catch, although they were occasionally caught while netting for fish, by feeling for submerged holes in banks, or by jumping on them as they swam past. As the waters dried up in the late cool and hot seasons the snake-necked tortoise aestivated in the drying muddy pool beds. The exposed dry beds would

be examined for tell-tale lumps and cracks which indicated a buried tortoise. The tortoise was then dug out with digging sticks or a convenient unmodified stick. Tortoises considered too small for eating were returned to the hole and covered.

Captured tortoises would occasionally be kept alive until required. This could be for several hours to a few weeks. They were kept in steep sided pits. Today they are often kept in water-filled drums.

The tortoise was killed by clubbing, breaking the neck by bending or, more commonly in recent times, by cutting its throat. It was then thrown onto an open fire for a preliminary 'cooking', removed and the lower plate broken off, either by hand or with an axe. The guts were removed. The tortoise was then replaced on the coals belly-up, with the belly plate restored and held in place by a heated rock, if available. The belly-up position ensured the retention of fluids which made a popular 'gravy'. The prepared tortoises would be cooked on the open coals or, if a large number was caught, in a ground oven.

Tortoise eggs are available in the middle to late cool season between July and August. They were cooked in a ground oven by being sandwiched between two thick layers of grass.

Freshwater crocodile

Freshwater crocodile were available all year in the permanent pools of the rivers and billabongs. They formed an occasional supplement to the meat diet. Crocodiles were caught mainly by spearing, and occasionally while netting for fish, or by hand. Crocodiles were also sometimes affected by fishing poisons.

When caught by hand, as when feeling in submerged holes in the banks for fish and tortoise or when feeling pool bottoms for waterlily roots, the hunter, feeling a crocodile, would slowly run their hand up the body to the jaws. The jaws would be held shut, the tail grabbed and the crocodile dragged onto the bank where its jaws would be tied. The legs would also be tied if it was intended to keep the crocodile alive, otherwise it would be killed immediately by an axe or club blow to the back of the head.

Small crocodiles would be cooked whole after gutting. Larger crocodiles – more than 100 cms in length – would be butchered and cooked. Cuts would be made along the spine and the crocodile spread out. The tail was cut off and the body quartered. The flesh was then cooked in a ground oven.

Crocodile eggs became available around August. The eggs would be found in sandy banks along the watercourses, the hunter often following the recent track of the mother. Eggs were cooked in a ground oven in the same manner as tortoise eggs.

Sugarbag

'Sugarbag' is the colloquial name given to the hive of stingless insect species collectively known as 'native bee'. The name 'sugarbag' includes the honey, pollen, wax and residues of the hive. Sugarbag is included in the category of small game as it was both a regular and important animal-derived food and was one of the targets in the small game hunting and foraging strategy.

Sugarbag was exploited throughout the year, and was usually a part of the daily diet. In terms of quality and quantity it is at its best when the major trees flower around the end of the hot season, through to the early wet season.

Sugarbag is found in trees, termite mounds, and in crevices in rock formations. The best quality sugarbag was found in the trunks and branches of trees in well-watered country where flowering trees were more abundant. It was located by watching out for the small fly-like bees and the tubular entrance to the hive. When the hive was in trees the hunter would knock the trunk or branch in order to locate the position of the hive. They would then cut a small hole below the hive. If possible this hole would be large enough to insert a hand and extract the hive largely intact. Alternatively, when a hand could not be inserted, a stick, usually around 50 cms long and with one end frayed by pounding, would be inserted into the hole and up into the hive. The honey would flow down the stick into a bark container. The solid remainder of the hive would then be removed by prodding with the stick. If possible, wood chips and some wax would be used to patch the hole to give the hive some chance of re-establishing.

The main reason given for the cutting of a small hole was that it was too hard to make a larger hole with a stone axe. With the advent of steel axes it is now easier to cut directly to the hive.

Sugarbag in termite mounds and rock formations was called 'ground sugarbag'. Wherever possible it was excavated and extracted in a complete package so as to prevent soil contamination. In all cases a hive could produce up to a litre of honey, wax, and pollen. This was eaten with no further preparation. The wax would be chewed and kept for later use in hafting. Occasionally, and especially with badly mixed hive contents, the residues would be mixed with water to dissolve the honey and the mixture was drunk by straining through a bundle of dry grass. There are some reports that the wax was used as a depilatory by ancestors, an act which Garawa men recount with awe.

Sugarbag is classed by the Garawa into two forms: 'boy' sugarbag and 'girl' sugarbag. 'Boy' sugarbag is usually found in tree branches and is identified by its long waxy hive entrance and its greater honey yield. The 'girl' sugarbag, found in tree trunks and ground sources, has a shorter, wider hive entrance and contains more pollen than honey.

Miscellaneous Species

Numerous other species of small mammals, reptiles, and birds were exploited opportunistically. These served to supplement the major meat sources and did

not form a regular or reliable part of the diet. Animals in this group include dingoes, bird species, smaller wallabies and bandicoots. While a variety of animals could be hunted, only a small proportion were regularly exploited in quantities and frequencies sufficient for them to be considered animal staples.

Summary

Small game species could be either specifically targeted or exploited opportunistically, in both cases with some guarantee of a return. At certain times of the year particular species were more abundant and special effort, in the form of targeting and specialised techniques, was applied to exploit this abundance.

While capture of large game provided a greater quantity of meat in a single event, small game contributed more to satisfying the daily meat demand and provided diversity in diet.

Aquatic Game

This section describes the methods for the collection of several major fish species, including barramundi, black bream, catfish, rifle fish and 'cod', the two species of short-necked tortoises, freshwater crayfish, and mussels. These species are defined as 'aquatic' due to their reliance upon permanent waters. Methods used were often indiscriminate in terms of a precise target and could be used to capture a variety of species.

To some extent the exploitation of aquatic game continued throughout the year. In the months between December and August, when the water levels are reasonably high, aquatic animals provided a minor supplement to a meat diet targeting terrestrial fauna. It was only during the hot dry months of August to late November that aquatic game became a major part of the diet. This marked seasonality was due to two main environmentally determined factors. Firstly, the majority of the Garawa population would shift from permanent waters during the wet and cool seasons to exploit the seasonally abundant terrestrial game. Secondly, the techniques and technology used in the exploitation of aquatic game were inefficient when there was abundant or flowing water.

The most common techniques were general foraging, netting, log traps and weirs, and 'poisons'. General foraging was practised all year while the other specialised techniques were restricted to the drier hot season when water levels dropped rapidly to form small, still pools.

General foraging

This involved the opportunistic capture of aquatic animals and the collection of shellfish. Hunters would occasionally spear animals which swam within range. Tortoise would be captured by jumping on them as they swam past. People looking for waterlily roots or feeling submerged holes in banks would catch fish, tortoises, water snakes, and small crocodiles.

Mussels were easily collected throughout the year by simply feeling in the mud and sands in the shallow pool edges. Small numbers of mussels would be cooked in the coals of an open fire while large quantities would be cooked in a suitably sized ground oven. After cooking the meat would be removed from the shells and put in a paperbark container for transport back to the main camp. The shells would be piled back into the fireplace for 'burning', as described above.

Netting

The explorer Augustus Gregory passed through the region in 1856 and reported ' . . . a fishing-net made neatly of twisted bark, the mesh one and a half inch, the length perhaps thirty feet . . . ' (Gregory 1884: 13).

All aquatic game could be caught using nets. These were manufactured from bark and suitable grasses and were up to 10 metres long. Smaller nets of up to a metre in length were occasionally used as scoop nets. The larger nets had poles at each end with one in the middle to serve as a 'spreader'. The hunters would drag the net through the water, usually up to chest deep, and drive, manoeuvre, and surround the catch in the shallows where it could be caught by hand, clubbed, or speared. The nets were relatively fragile and could not contain a weight of game out of the water. Netting was used as pools became smaller and shallower in the hotter weather. The operation usually involved a minimum of three people.

Trigger (1987: 78-79) has reported similar accounts of net use from the eastern Garawa and Ganggalida people.

Log traps and weirs

In the middle and southern parts of the study region, above the range of tidal influences on the rivers, hollow logs were used as simple fish traps. These were used to catch catfish, cod, black bream, and freshwater crayfish. A suitably sized hollow log would have one end blocked with a wad of grass. It would then be placed in the water overnight, close to the bank. The next day the mouth of the log would be blocked and the log removed onto the bank. The end was then unblocked and the contents emptied out. A number of these traps could be in operation at any one time, spread around one or more waterholes.

In the northern part of the study area, on the flatter coastal plains, the inland river levels were somewhat affected by tidal movement. Here small weirs of branches would be placed across shallow channels to hold fish when the water level dropped. Leichhardt reported similar weirs in his 1845 expedition (Leichhardt 1847: 396, 402).

'Poisons'

Poisoning was the most frequently used fishing technique, though its application was restricted to the

hot season and to the smaller pools (less than 15 metres across). The branches and bark of several local tree species (*e.g. Barringtonia* spp., *Acacia* spp., *Eucalyptus* spp.) were suitable for poisoning the water. These would be broken up and dropped into the pools. The sap would make the water 'soapy' and the fish would rise stupefied to the surface where they could be speared, clubbed, scoop netted, or collected by hand.

Some poisons would also affect small crocodiles and tortoises by irritating eye, nose and mouth membranes and forcing the animals to the surface where they were captured.

Poisons took some time to degrade and disperse. Once a pool had been poisoned it was considered unsuitable for drinking water until flushed by the coming rains. The Garawa would therefore take care to maintain an unpoisoned body of water.

Trigger (1987: 78) has also briefly reported on the similar use of poisons by groups to the east of the study area.

Another technique which can be considered 'poisoning', as it affects the water quality, was the dragging of branches through the water to stir up the mud. This also forced fish and other animals to the surface where they could be caught.

Summary

Methods of capture were applicable to a variety of aquatic fauna. Specific aquatic game species were rarely individually targeted. Although it was always available, aquatic game became a major part of the meat diet in the hot months prior to the summer rains. Increased availabilty of aquatic game, due to its concentration caused by falling water levels, coincided with a drop in the number and condition of terrestrial fauna and a hot season congregation of the Garawa population around the permanent waterholes.

Discussion

The principal aim of this paper has been to provide basic ethnographic accounts of Garawa game hunting and preparation methods. The three summary classes described incorporate several methods, both general and specialised. These strategies more accurately match broad categories of animal size and habitat than specific species.

It is likely that the methods described here were those most commonly used in the day-to-day quest for game by the Garawa. The descriptions of the correct ways of catching and preparing game are consistent within and between informants' accounts. Indeed, where direct observation was possible, this showed a strong adherence to the verbal descriptions. Where exceptions did occur it was made clear that this deviation was anomalous and the result of certain, usually 'non-traditional' influences (for example, a decision to break camp prematurely to be in time to meet a mail plane).

The strategies provided here represent Garawa models of correct subsistence behaviour as much as they reflect real behaviour. Though special circumstances would produce deviations from these models these were usually short term. Through these generalised accounts the Garawa tacitly acknowledge that adherence to models of proven basic subsistence methods was as crucial to the physical well-being of the Garawa community as adherence to social laws was crucial to their psychological and spiritual well-being.

It may be argued that the data presented here adds little to the data on Aboriginal hunting methods known from studies elsewhere in northern Australia. The significance of the Garawa data, though, lies not only in its differences but also in its similarities to these other regional studies.

The existence of similar strategies of hunting and food preparation in conjunction with different land use patterns in different environments supports the hypothesis that optimum yet simple strategies existed for the exploitation of Australian game animals. Further, these strategies were adapted more to animal size than to specific species. This allowed them to be applied equally effectively in different environments.

As noted earlier this paper stems from a broader study into regional land use and site patterning for the purpose of developing models applicable to archaeology. Data on game hunting and preparation is most likely to appeal primarily to archaeologists. While often willing to apply ethnographic analogies in their interpretations of archaeological debris, archaeologists are rightly cautious about assuming directly analogous associations between behaviour and debris when the two are separated by space, time, and environments. There is an undertandable preference for deriving analogies from a similar environmental context to the original environmental context of the archaeological materials.

The Garawa material provided here, although general, contributes to the very limited data base available for transitional sub-humid to semi-arid environments. In so doing it also supports the hypothesis that, within Australia, basically similar strategies for game exploitation often existed across differing environments. If such similarities can be identified over space it may be feasible to suggest that common strategies also existed over time. This hypothesis requires further testing through more detailed comparative studies. It cannot be denied though, that the generation of models of behaviour – social, economic or technological – on the basis of the identification of regularities in behaviour within and between regions, can be of considerable value in the interpretation of archaeological models. Binford (1983), for example, has applied the results of his own

ethnographic work amongst the Nunamiut of northern America to the interpretation of the archaeology of the French Palaeolithic. The Australian record has the potential to contribute to the development of behavioural models applicable to both Australian and overseas studies. To do so, though, it must first modify its tendency to over-emphasise specifics. As Clarke has stated (1978: 100):

> This specification problem is the single greatest barrier in detecting significant correlations between regularities in archaeological and anthropological analyses . . .

Acknowledgments

Information forming the basis of this paper was provided by Don and Eileen Rory and their family, Old Davey, Laura, Clara, Godfrey Noble, Roy Dixon, Jacky Green, Blue Bob, Dinny McDinny, and the other members of the Garawa community resident in Borroloola and Robinson River Station.

Assistance with funding of fieldwork has been provided by the L. S. B. Leakey Foundation, La Trobe University Humanities Research Grants, and Ann Robb.

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FIRST HEXACTINELLIDA (PORIFERA) (GLASS SPONGES) FROM THE GREAT AUSTRALIAN BIGHT

HENRY M. REISWIG

REISWIG, H. M. 1992. First Hexactinellida (Porifera) (glass sponges) from the Great Australian Bight. *Rec. S. Aust. Mus.* **26**(1): 25-36.

The four species of Hexactinellida described are the first members of the class reported from southern Australian shelf and slope waters. The large vasiform *Pheronema amphorae* n. sp. is the first known member of the genus outside the Atlantic region bearing a well-developed annulus. *Euplectella regalis*, previously known only from the holotype, is represented by two new individuals. A very large specimen of *Regadrella okinoseana*, exhibiting the extremely rare feature of sieve plate fusion, offers new data which permits synonymisation of all stauractin-bearing regadrellids.

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Knowledge of the hexactinellid sponge fauna is rudimentary in all but a very few marine communities. Few are more inadequately documented than that of the continental shelves and slopes of the south and west coasts of Australia. Only two major oceanographic expeditions have sampled in or near these waters. In 1874 H.M.S. 'Challenger' collected four new species (Schulze 1887), all from oceanic stations well south of the continent (Fig. 1) – Sta. 157: *Holascus polejaevi* Schulze and *Caulophacus pipetta* (Schulze) (as *Balanella*); Sta. 158: *Hyalonema conus* Schulze; Sta. 160: *Holascus fibulata* Schulze. During the British, Australian and New Zealand Antarctic Research Expedition (BANZARE), the R.R.S. 'Discovery' passed over the shelf in 1930 and offshore in 1931. While results of work on the BANZARE Antarctic sponges have been published, those on the Australian and subantarctic sponges, planned for a separate account (Koltun 1976), remain unreported.

This report thus represents the first published record of identified Hexactinellida from the continental shelf and slope waters of southern Australia. The four species were collected at separate stations in the Great Australian Bight (Fig. 1) by F.V. 'Adelaide Pearl' and F.V. 'Saxon Progress' during July and August 1988. The specimens, which were kindly made available for study by Shane Parker, Curator of Lower Marine Invertebrates, South Australian Museum (SAM), are now in the permanent collections of that institution.

Systematic Descriptions

Class Hexactinellida Schmidt, 1870
Subclass Amphidiscophora Schulze, 1899
Order Amphidiscosida Schrammen, 1924
Family Pheronematidae Gray, 1870

Genus *Pheronema* Leidy, 1868

Diagnosis

Schulze (1904) (emended): body form usually cup- or bowl-like with a distinct gastral cavity, but extremes include plate and spherical shapes; gastral margin usually defined by a complete or incomplete fringe of marginal prostalia; lateral body surfaces bear long pleural prostalia singly or in tufts; basal prostalia project from the inferior body surface in numerous distinct bundles but occasionally as single spicules or in a single bundle; large prostalia are exclusively monactins, either sceptres or bidentate anchors with strongly or gently recurved flukes; smaller macruncinates are components of all prostalia bundles; basal rays of pinules are straight and oriented perpendicular or slightly oblique (downward) to the pinular ray.

Pheronema amphorae n.sp.
(Figs 2-4)

Material Examined

Holotype: SAM S696, continental shelf, 183 km south of Cape Adieu, South Australia, 33° 42′S, 132° 25′E, 130 m depth, 12 August 1988, coll. B. Jubb, F.V. 'Saxon Progress', Sta. C4, trawl, in ethanol.

Diagnosis

Pheronematid with deep cup-shaped, nearly tubular body. Large terminal osculum bordered by fringe of sceptres as marginalia and encircled a short distance below by an annulus of long sceptres as pleuralia. Thorned, gothic-arched basalia, 126-264 μm across the anchor, project from the lower half of body in distinct bundles. Uncinates in four distinct size classes ranging from 168 to 1816 μm, in mean length. Microscleres include two size classes of amphidiscs, spiny oxyhexactins and oxypentactins, and siliceous 'pearls'.

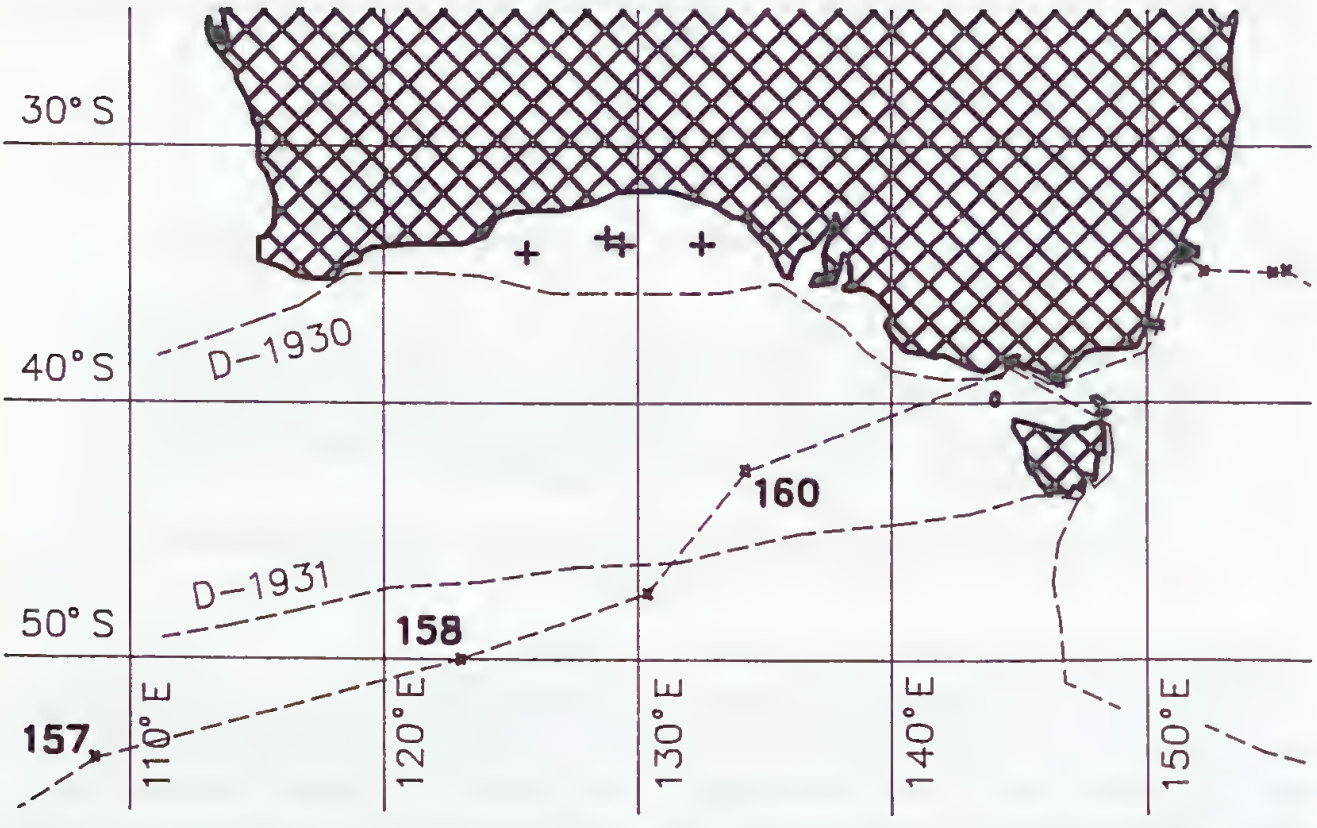


FIGURE 1. Map of southern Australian waters with collection stations reported here (+) and tracks of 'Challenger' (with station numbers), and 'Discovery' (equal longitude/latitude computer projection).

Description

Morphology: The only specimen, moderately damaged during collection with loss of much of the oscular margin (Figs 3 and 4), is reconstructed in Fig. 2a. The body is vasiform or almost tubular, with dimensions: 22 cm length, 13 cm diameter, 7 cm oscular diameter, and 1.8-3.2 cm wall thickness. The texture is soft and fragile, with internal structure visibly cavernous. The oscular marginal fringe, projecting 1.3-2.5 cm, consists mainly of large sceptres in bundles of 5 to 20 spicules. Most are 70-100 μm in diameter and broken distally, so they remain as smooth shafts with acute internal ends. Their monactin nature is established by associated younger developmental stages. Macruncinates comprise approximately 10% of the fringe spicules.

The external surface is generally smooth in overall contour and consists of four recognizable zones (Fig. 2a): a felt zone approximately 2.5 cm wide bordering the marginal fringe, an annular zone of long sceptres *ca* 0.5 cm wide, a 'smooth' zone extending over the remainder of the upper one-half of the body, and a basal zone extending over the lower body half.

The felt zone is covered by a dense nap of vertically oriented spicule bundles, extending 0.2 cm above the body surface. The bundles consist of short, thin sceptres (85%, 10-25 μm diameter) and macruncinates (15%). Few dermal pinules cover the surface between bundles. The annular zone, like the marginal fringe, consists of very large, often broken sceptres, up to 160 μm diameter, projecting up to 5 cm, with spicules of the felt level continuing as a lower stratum. A few very long, thin 'silk' spicules, 7 μm diameter by 10+ cm in length with broken distal tips, project with the longer sceptres. The smooth zone is bounded by a porous surface covered by dermal pinules with a sparse population of the small sceptres and macruncinates of the felt zone persisting. Long thin basalia occur occasionally in this zone, projecting 5-15 cm singly or in small groups of up to five. The basal zone includes components of the smooth zone with addition of basal anchor bundles spaced 0.5-1 cm apart. The bundles are 0.2-0.4 cm in diameter and consist of 10 to 50 basal anchors of all sizes, with single spicules reaching over 300 μm diameter. The basal terminus of the body is bare of root bundles. A few sceptres up to 3 cm long also occur in the root bundles. Bundles, up to 32 cm in length, intertwine to form a massive anchor mass. In natural position these probably radiate evenly through a hemisphere of bottom sediment.

The gastral surface is smooth and even, covered only by a layer of gastral pinules. There are no openings of large exhalant canals nor indication of a special gastral sieve.

Megascleres (Table 1): No proper diactine megascleres (uncinates excluded) occur in this species, as characteristic of the genus. Large pentactins (not figured) serve as parenchymal principalia as well as hypodermalia and hypogastralia. They are smooth-

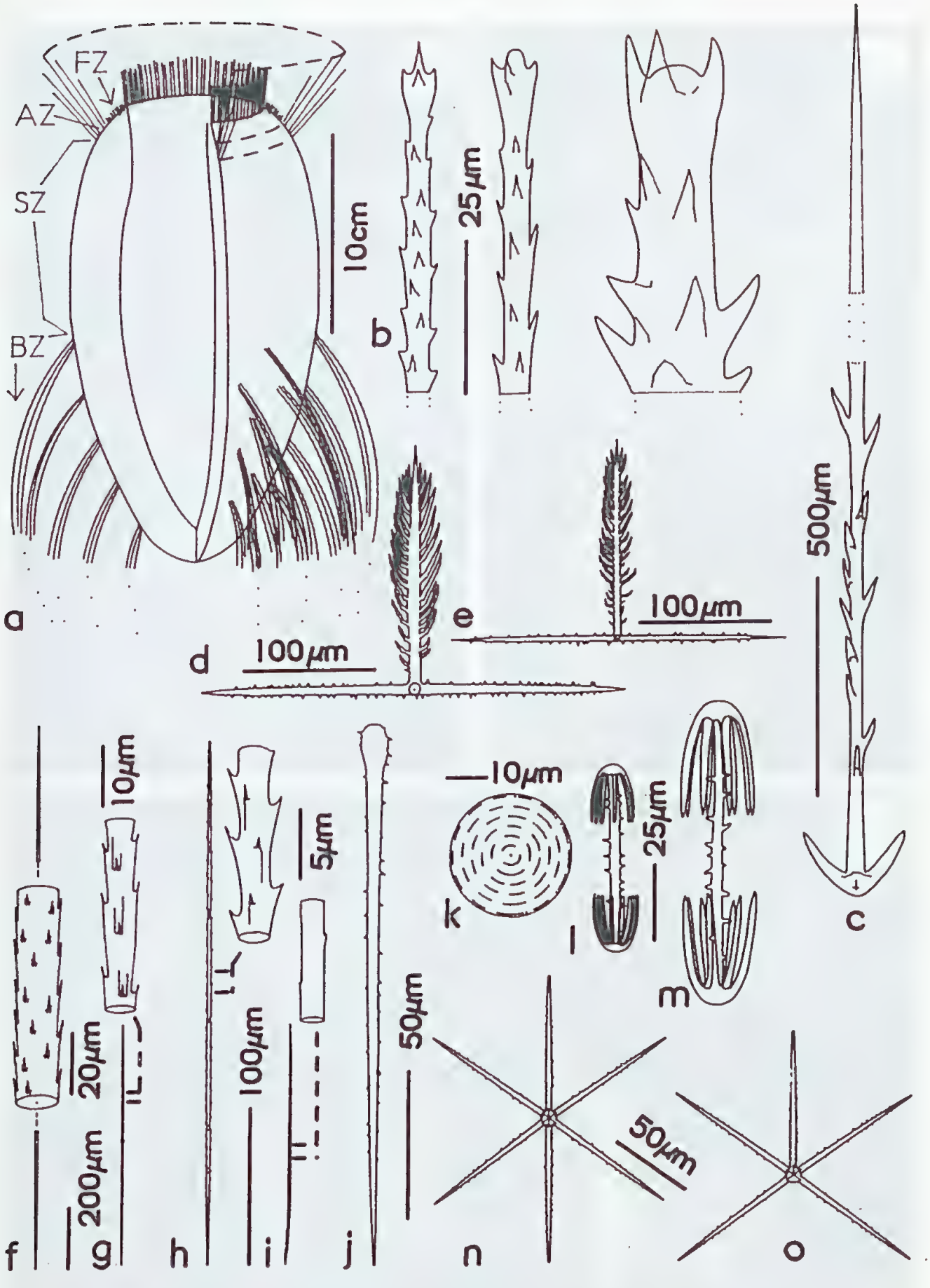
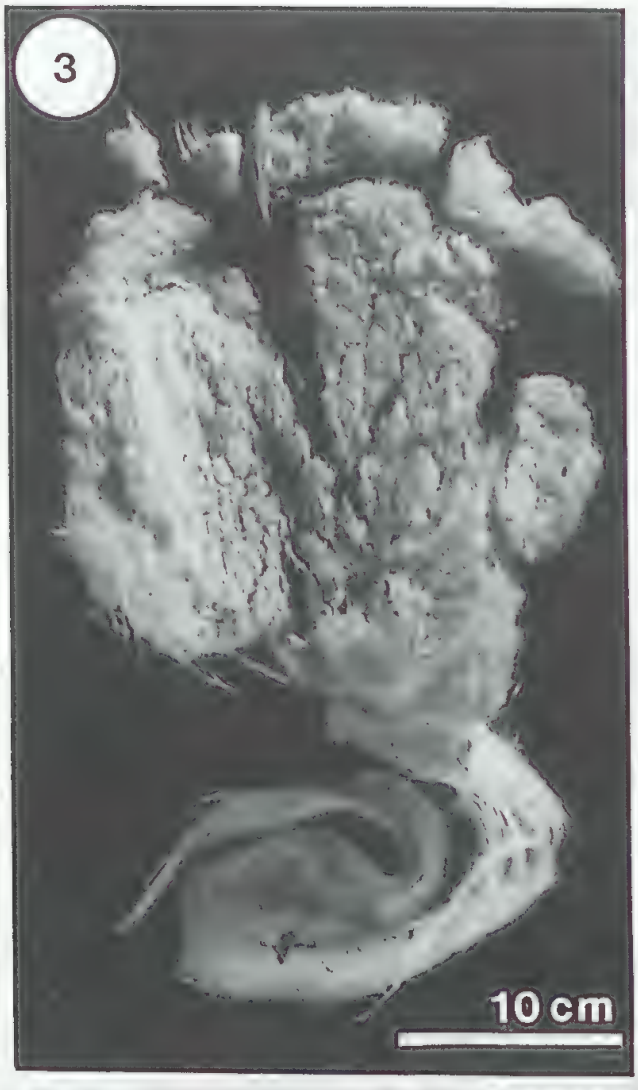
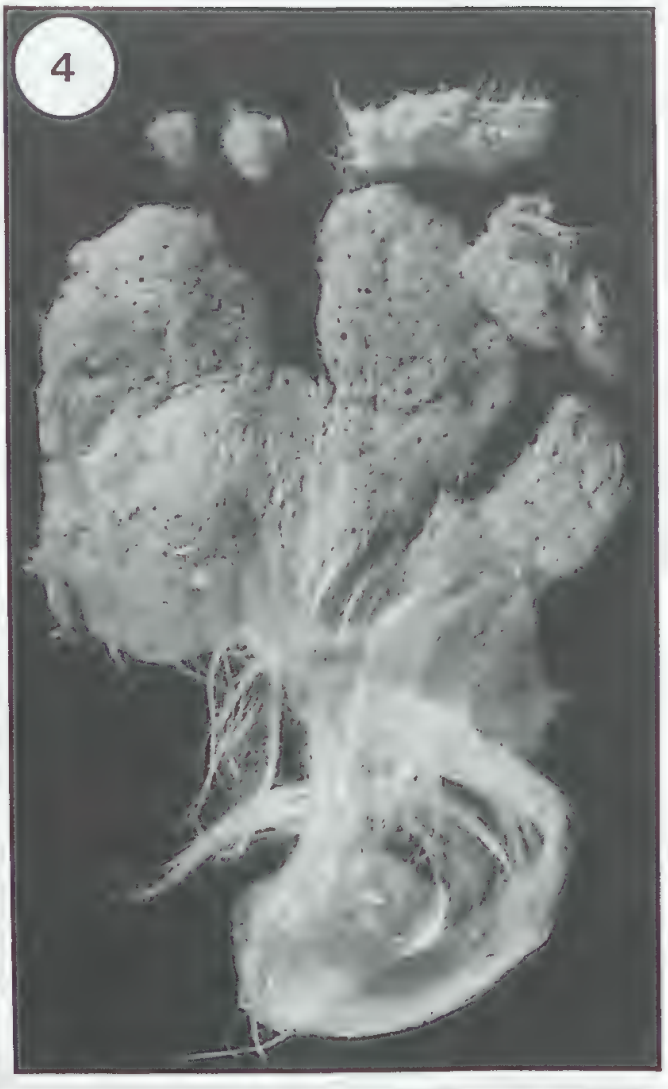


FIGURE 2. *Pheronema amphorae* n. sp. holotype SAM S696. **a**, reconstruction of body form with external zonation (see text for explanation); **b**, sceptre tips; **c**, basal anchor; **d**, dermal pinule; **e**, gastral pinule; **f-i**, uncinates 1-4; **j**, monactine club; **k**, siliceous 'pearl'; **l**, micramphidisc; **m**, mesamphidisc; **n**, spiny mesohexactin; **o**, spiny mesopentactin.


3
10 cm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5
10 cm

surfaced and either regular when associated with body surfaces or irregular when parenchymal. Monactine sceptres, or 'cuspidates', (Fig. 2b) occur as a major component of dermal spiculation, including the marginal fringe and annulus. Younger (shorter) sceptres have distal spines directed outwards toward the spicular centrum with only the proximal quarter of the shaft smooth. As spicules increase in size the relative proportions of shaft texture are gradually reversed until, in the largest intact examples, spination is restricted to a small distal section. Uncinates were divided into size classes by preliminary size-frequency analysis of 600 random length measurements. The two larger sizes (Figs 2f and g) have straight shafts and distinct barbs. The smaller classes (Figs 2h and i) both lack barbs at the light microscope level; the larger of the two is straight-shafted and bears sharp spines while the smallest is distinctly curved and carries only bracket facets. Basalia (Fig. 2c) have typical bidentate anchors and coarsely thorned distal shafts. The anchor is of the gothic arch form. No smooth-shaft basalia are present, thorns being especially pronounced at the earliest formative stages. Thin filiform spicules or 'silks', *ca* 7μm in diameter, are present in low abundance in the annulus. They bear sharp proximal tips but are universally broken distally. Slight swellings at regular intervals along the shaft of some examples are interpreted as incipient thorns. These are probably monactins, as are all other prostalia, but of uncertain taxonomic significance.

Mesocleres (Table 1): Recognition of this major category of spicule is forced by similarity of form and size between pinules, usually categorized as megascleres, and parenchymal hexactins, usually categorized as microscleres (*e.g.* microhexactins). Spicule dimensions alone are inadequate to define major spicule categories within Hexactinellida as evident in the range of uncinate size classes above. Dermal and gastral pinules (Figs 2d and e) have typical fir-tree pinulus and perfectly perpendicular and completely spined tangential rays. A few exhibit curvature and reduced spination of the pinular ray, but these variations are rare. Mesoxyhexactins and mesoxypentactins occur as typical parenchymal intermedial spicules (Figs 2n and o). They are completely covered in short spines, and thus intergrade with pinule variants exhibiting reduction of pinulus spination. The distinction between these classes remains nonetheless obvious. Spined monactine clubs (Fig. 2j), or acanthotylostyles in demosponge terminology, occur sparsely as parenchymal intermedials. While uncommon, they are sufficiently abundant and consistent in form to warrant recognition as a distinct spicule type in this species. They may be of rare occurrence in the wider group, Hexactinellida.

Microscleres (Table 1): Amphidisc classes were

TABLE 1. Spicule dimensions of *Pheronema amphorae* n. sp. in μm unless otherwise noted.

Spicule type	Length ± SD	(range)	N	Width ± SD	(range)	N
Macropentactin						
tangential ray	3685±2000	(547-8533)	50	46.7±13.7	(21.6-75.1)	50
unpaired ray	2747±1493	(543-6537)	50	–	–	–
Sceptre	to 6+ cm	–	–	to 160 μm	–	–
Uncinate 1	1816±337	(1217-2749)	50	13.6±2.3	(8.5-19.0)	50
Uncinate 2	796±174	(533-1293)	50	5.8±1.4	(3.5-11.0)	50
Uncinate 3	342±95	(178-621)	50	2.4±0.6	(1.3-4.5)	50
Uncinate 4	168±52	(73-281)	50	1.5±0.3	(1.0-2.5)	50
Basal anchor	to 32+ cm	–	–	216±27*	(126-264)	50
Silk	to 10+ cm	–	–	–	(7.0-8.3)	–
Dermal pinule, pinulus	144±32	(83-242)	50	8.5±1.4	(5.7-11.6)	50
tangential ray	130±20	(87-186)	61	7.1±1.1	(5.0-9.7)	50
Gastral pinule, pinulus	124±30	(61-251)	67	6.9±1.1	(4.2-10.8)	50
tangential ray	129±18	(72-172)	61	6.3±1.1	(3.7-10.5)	50
Mesoxyhexactin ray	95±19	(64-154)	66	3.3±0.5	(2.7-4.4)	25
Mesoxypentactin ray	99±20	(58-166)	66	3.5±0.8	(2.1-4.7)	25
Monactine club	169±32	(119-314)	45	–	–	–
Mesamphidisc	102±11	(88-138)	50	24.8±3.9	(19.2-37.7)	50
Micramphidisc	60±7	(45-77)	50	15.7±2.7	(11.3-23.1)	50
Pearl (diameter)	31.2±12.4	(15.8-82)	50	–	–	–

* widest distance between anchor teeth tips.

◄

FIGURES 3-5. *Pheronema amphora* n. sp. and *Euplectella regalis*. **3 and 4**, internal (left) and external (right) views of *Pheronema amphorae* holotype, SAM S696; **5**, *Euplectella regalis*, SAM S693 (upper) and S694 (gross external transverse ridges are artefacts of the packaging process for specimen transport).

identified by length-frequency analysis of 754 randomly selected spicules; a clear bimodal distribution was obtained. Mesamphidiscs (Fig. 2m) have elongate 8-toothed umbels and a mean width/length ratio of 0.260. Micramphidiscs (Fig. 2l) have proportionately shorter and narrower umbels bearing 9-*10.5*-13 teeth and a mean width/length ratio of 0.243. Both amphidiscs are distributed throughout the parenchyme and dermal tissues, but are not common in near-gastral tissues. Extensive search for intrinsic macramphidiscs yielded negative results. Spherical 'pearls' (Fig. 2k) of obvious intrinsic production were sufficiently common to accept these as a recognizable skeletal element in this specimen.

Etymology

The name refers to the body form, which resembles the basal portion of an amphora.

Remarks

Schulze's (1904: 151) definition of *Pheronema* excludes the species assigned to *Poliopogon* at that time and is here considered valid. Ijima's (1927: 9) suggestion to move *Poliopogon gigas* Schulze to *Pheronema* is rejected because supporting arguments were not presented. Tabachnick (1988) supported Ijima's suggestion, without assignment of *P. gigas*, and attempted to redefine *Poliopogon*. His redefinition must be ignored since it neglects consideration of principalia, pleuralia, marginalia, and uncinates altogether and, as proposed, would exclude the type species *Poliopogon amadou* Thomson. More recently (Tabachnick 1990) he reassigned *P. gigas* as the type of a new genus, *Schulzeviella*, which differs from *Poliopogon* by body form and presence of microxydiacts. In view of the great variability of body form and microsclere complement accepted for *Pheronema*, these characters seem inadequate for distinction of genera. A revision of the relationship between the three genera must include a thorough and informed review of all species involved.

The genus *Pheronema*, understood to exclude *Poliopogon gigas*, contains 19 species and one subspecies which presently hold nomenclatural validity, although the genus has not been revised and some are probably synonyms. Most are easily compared to *P. amphorae* but a few are inadequately known due to the poor state of the material available to the describer, or to the lack of diligence by the original author. The single character, body form, distinguishes *P. amphorae* from all other species, but alone is insufficient for taxonomic action. The abbreviated inventory of additional character differences presented here is adequate to demonstrate the distinction of the new species. Principalia include hexactins in *P. conicum* Lévi & Lévi (1982), *P. pepo* Ijima & Okada (1938), and *P. placodium* Ijima & Okada (1938), but are exclusively pentactins in *P. amphorae*. The basal anchor is crescentic in *P. conicum*, *P. echinatum* Ijima (1927), *P. giganteum* Schulze (of Schulze 1886, not Ijima 1927), *P. hemisphaericum* (Gray 1873), *P. ijimae* Okada (1932) (of Lévi & Lévi 1989, not Okada 1932) but gothic-arched in *P. amphorae*. Anchor form was not given in descriptions of *P. barbulosclera* Lévi (1964), *P. pilosum* Lévi (1964), *P. semiglobosum* Lévi & Lévi (1982), and *P. surugensis* Okada (1932). Forms lacking marginalia are *P. annae* Leidy (1868), *P. gigantea* (of Ijima 1927, not Schulze 1886), and *P. ijimae*. Spiny mesoxyhexactins are abundant in *P. amphorae* but are absent in *P. carpenteri* (Thomson 1869), *P. globosum globosum* Schulze (1886), *P. grayi* Kent (1870) and *P. megaglobosum* Tabachnick (1988). A sieve plate, lacking in *P. amphorae*, is present in *P. globosum kagoshimensis* Okada (1932), *P. raphanus* Schulze (1894), *P. semiglobosum*, and *P. nasckaniensis* Tabachnick (1990). Micramphidiscs are much smaller than those of *P. amphorae* (entirely outside the range) in *P. barbulosclera*, *P. giganteum*, *P. globosum globosum*, *P. raphanus*, *P. surugensis* and *P. weberi* Ijima (1927). All of these species differ from *P. amphorae* in several other characters. *Pheronema pilosum* remains the most difficult member to compare with the new species due to brevity of its original description (Lévi 1964). Differences in body form, dimensions and spination of dermal pinules, and amphidisc sizes indicate the two forms are quite distinct, but form and size of basal anchors and presence or absence of mesoxyhexactins remain unknown for *P. pilosum*. The new species is most closely related in body form and overall spiculation to *P. carpenteri* and *P. grayi* of the North Atlantic.

The nominal taxa, *P. parfaiti* Filhol (1885) and *P. saccus* Schmidt (1870), must be considered unrecognizable, as concluded by Schulze (1904), until the original specimens are found and their characters assessed. Schulze's (1893) argument that *P. pourtalesii* Schmidt (1870) must be referred to *Rossella* is accepted here. *Pheronema circumpalatum* Schulze (1894), as affirmed by Schulze (1902), is a junior synonym of *P. raphanus*. *Pheronema velatum* is a nomen nudum. It was used without description or indication by Carpenter & Jeffreys (1870) as a provisional name for a Gibraltar specimen later figured as *Rossella velata* by Thomson (1873), now the only recognized species of *Mellonympha*.

Distribution

Great Australian Bight, 130 m depth.

Subclass Hexasterophora Schulze, 1899
Order Hexactinosida Schrammen, 1910-12
Suborder Clavularia Schulze, 1886
Family Farreidae Schulze, 1886

Genus *Farrea* Bowerbank, 1862

Diagnosis
See Ijima (1927: 130).

Farrea occa occa Bowerbank, 1862, Carter, 1885

Abbreviated synonymy:
unnamed – Owen, 1857: 121 pl. XXI figs 9, 9a.
Farrea occa Bowerbank 1862: 1118; 1864: 204, pl. XX, fig. 311 (not pl. XV, fig. 277); 1869: 339 pl. XXIV, fig. 7 (not figs 1-6); Carter 1885: 388 pl. XII, pl. XIII, figs 1-11; Schulze 1887: 277 pl. LXXI-LXXII, LXXVI.
Farrea occa occa Ijima 1927: 131; Burton 1959: 153; Reiswig 1990: 735.

Material examined
One specimen (fragments): SAM S813, continental slope, 232 km east of Cape Arid, Western Australia, 34°03′S, 125°31′E, 1 011-1 020 m depth, 31 July 1988, coll. K. L. Gowlett-Holmes, K. J. Olsson and M. Cameron, F. V. 'Adelaide Pearl', Sta. 15, trawl, in ethanol.

Description
The specimen consists of three main fragments, two of which retain soft tissues, plus numerous small fragments, all presumably from a single original specimen. The largest fragment, 2.8 cm in height by 1.8 cm width, is composed of thin-walled tubules 0.7 to 1.0 cm in diameter, similar to the Japanese specimen of Carter's (1885) redescription. The frame is primarily single layered and square meshed, with conspicuous asymmetry in length of spurs on the two faces. Spiculation includes dermal and gastral spined pentactins, oxyhexasters (99-119 μm diameter) which are often hemihexastrous and merge with oxyhexactins, and pileate clavules projecting in radial bundles in the dermal layer. Terminal rays of the oxyhexasters are longer than primary rays in the ratio 1.3. No tylohexasters or other forms of clavulae are present.

Remarks
On the basis of body form and spiculation, the specimen is assigned to the typical subspecies *Farrea occa occa* in spite of slight differences in proportions of the oxyhexasters and absence of anchorate clavules.

Distribution
Cosmopolitan

Order Lyssacinosida Ijima, 1927
Family Euplectellidae Gray, 1867
Subfamily Euplectellinae Ijima, 1903

Genus ***Euplectella*** Owen, 1841

Diagnosis
See Ijima (1927: 327).

Euplectella regalis Schulze, 1900
(Figs 5-8)

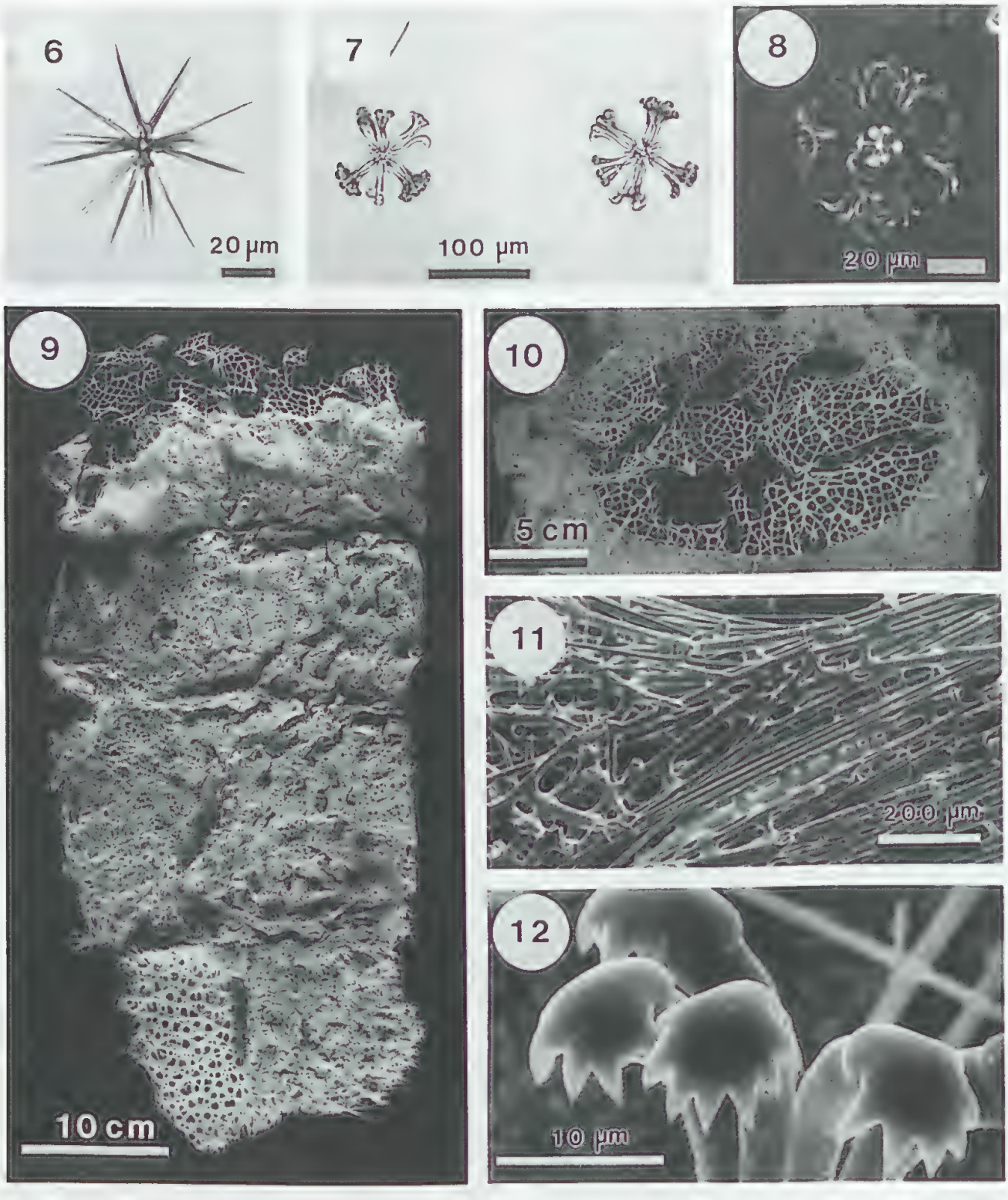
Euplectella regalis Schulze 1900: 24, pl. VI, figs 1-9; 1902: 61, pl. XXII, figs 1-9, 1904: 132 (key); Ijima 1901: 58 (key); 1927: 327, 334; Burton 1959: 154; Reiswig 1990: 738.

Material examined
Two specimens: SAM S693, SAM S694, continental slope, 194 km south of Eucla, South Australia, 33°26.8′S, 128°41′E, 956-973 m depth, 28 July 1988, coll. K. L. Gowlett-Holmes, K. J. Olsson and M. Cameron, F.V. 'Adelaide Pearl', trawl, in ethanol.

Diagnosis
Euplectellidae with straight, cylindrical body; with nearly flat sieve plate bordered by a narrow marginal collar; local patches of parietal oscula in oblique or longitudinal and transverse rows; soft parietal ridges run obliquely; parietal principalia are stauractins with diactins and triactins as comitalia; oscularia are mainly stout pentactins; microscleres include oxyhexasters with short primary rays, floricomes with 3-to-10-toothed, palmate tips, sigmatocomes, and graphiocomes.

Description
Morphology: The two flattened specimens (Fig. 5) are the soft, flexible upper portions of cylindrical individuals of unknown total length. Their respective dimensions (693, 694) are: length 41, 29.5 cm; diameter 8.0, 8.3 cm. Both have narrow marginal collars, 0.65-0.8 cm and 0.63-0.75 cm in width and well developed but soft and thin, oblique parietal ridges to 1.3 cm and 1.15 cm height respectively. Wall thickness varies from 0.30-0.45 cm in both specimens. Parietal oscula are irregularly distributed – in some areas in oblique series and in others in longitudinal and transverse rows. The sieve plates are nearly flat and typical in form. Synapticular fusion is evident only in the lower portions of both specimens.

Spiculation: Parietal principalia are tetractins (stauractins), with associated diactins, triactins, and few hexactins as comitalia. The sieve plate contains stout bent macrodiactins and a few macrotriactins and macrotetractins as principalia, long diactins and triactins as commitalia and short, stout pentactins and hexactins as superficial spicules. Sword hexactins and diactins form the major support elements in the general dermis, marginal collar, and parietal ridges. Parietal oscularia consist mainly of small stout pentactins (62%), but hexactins (26%), tetractins (6.5%), triactins (2.2%) and compass diactins (3.3%) occur (N=346). Four classes of microscleres are common – dimensions are based upon 25 spicules of each (693, 694; min-*mean*-max). Oxyhexasters (Fig. 6) have very short principal rays, 0.125 of radius, and 2-3-4



FIGURES 6-12. Microscleres of *Euplectella regalis* SAM S693 and *Regadrella okinoseana* SAM S695. **6-8**, oxyhexaster, two floricomes (incomplete), and sigmatocome (phase contrast) of *Euplectella regalis;* **9-12**, *Regadrella okinoseana:* **9**, external view; **10**, broken sieve plate; **11**, SEM of sieve plate beam showing synapticular fusion; **12**, SEM of floricome terminal ray tips.

terminals: 82-*95*-110, 86-*111*-128 μm diameter. Floricomes (Fig. 7) have 3-*7*-10 terminals: 90-*108*-124, 89-*120*-133 μm diameter. Sigmatocomes (Fig. 8) have 10-*12*-14 terminals: 49-*56*-*76*, 48-*60*-67 μm diameter. Graphiocomes are broken in all preparations: centra 21-*26*-30, 15-*21*-24 μm diameter; raphide terminals 110-*129*-147, 69-*113*-154 μm length. Anchors are unavailable.

Remarks

These specimens are excluded from the fourteen other valid species of *Euplectella* by nature of parietal and sieve plate principalia, parietal ridges, marginal collar, oscularia and presence of oxyhexasters. They agree with all major characters of Schulze's (1900) *Euplectella regalis* but differ in two details, the presence of graphiocomes (as predicted by Ijima 1901: 53), and the distribution pattern of parietal oscula (described as generally in longitudinal and transverse rows in the type specimen, Schulze 1900: 24). Only a small portion of the type of *E. regalis* is figured by Schulze (1900), so verification of his description of oscula distribution would require re-examination of the original specimen. Unfortunately that specimen may be too severely subdivided to resolve the pattern of oscula (2 jars with 3 pieces in the Natural History Museum, London; 3 jars in the Zoologisches Museum der Humboldt Universität, Berlin; main specimen probably in the Indian Museum, Calcutta). In spite of this slight difference, the two specimens are here accepted as the second and third known examples of the species. Both Australian sponges were probably larger than the type specimen which was complete with root tuft and measured 40 cm in length and 7-8 cm in diameter. The tendency for local areas of body wall to develop distribution of parietal oscula in longitudinal and transverse rows is accepted here as a variable character, along with slight differences that are expected to occur in proportions and dimensions of spicules. An emended diagnosis reflects these variations.

Distribution

Andaman Is., 741 m; Great Australian Bight, 956-973 m.

Subfamily CORBITELLINAE Ijima, 1902b

Genus *Regadrella* Schmidt, 1880

Diagnosis

See Ijima (1927: 335).

Regadrella okinoseana Ijima, 1896
(Figs 9-12)

Regadrella okinoseana Ijima 1896: 250; 1901: 223, pls VII, VIII; 1902a: 122; 1902b: 8; 1902c: 691; 1903: 18; 1927: 335; Schulze 1899: 115; 1900: 30; 1902: 67; 1904: 133; Topsent 1904: 375; 1928: 297; Wilson 1904: 35; Schrammen 1912: 182; Kirkpatrick 1913: 64; Reid 1964: cxxvii; Lévi & Lévi 1982: 292, pl. VI; Salomon 1990: 344; Reiswig 1990: 738.

Regadrella decora Schulze 1900: 30, pl. VI, figs 10-18; 1902: 67, pl. XXII, figs 10-18; 1904: 133; Ijima 1901: 223; 1927: 335; Burton 1959: 154; Lévi & Lévi 1982: 293; Reiswig 1990: 738.

Regadrella cylindrica Ijima 1927: 335, pl. VIII, figs 9-21; Reid 1964: xcii; Lévi & Lévi 1982: 293; Salomon 1990: 344; Reiswig 1990: 738.

Material examined

One specimen: SAM S695, continental slope, 232 km south of Eucla, South Australia, 33°45′S, 129°17′E, 999-1 110 m depth, 1 August 1988, coll. K. L. Gowlett-Holmes, K. J. Olsson and M. Cameron, F. V. 'Adelaide Pearl', trawl, in ethanol.

Diagnosis

Regadrellid with barrel-shaped body, slightly inflated sieve plate, wide marginal collar (cuff) and rigid, fused basal cup attached to solid substrate; lateral body wall bearing a connected network of smooth-edged ridges which circumscribe depressions containing small parietal oscula; principalia are large gently bent diactins; microscleres include distinctive oxystauractins, floricomes, and graphiocomes.

Description

Morphology: The specimen (Fig. 9) consists of the upper portion of a large individual of unknown total length. It is 48 cm in length and, although now flattened, was presumably oval in cross section, with major and minor diameters measured at the upper end of 22.9 by 14.5 cm. The marginal collar is well developed, up to 2.5 cm wide, and the ridges between the parietal depressions are *ca* one cm in height. Synapticular fusion of lateral wall spicules is absent from the upper 33 cm, and gradually increases from that point towards the torn basal end. The sieve plate, originally nearly flat in shape, is extensively broken due to synapticular fusion of the central half (Figs 10 and 11). Synapticular deposition gradually decreases marginally. The area bounding the junction with the body wall remains free of all but trivial traces of secondary silicification and is flexible.

Megascleres and mesoscleres (dimensions as min-*mean*-max, n=25): The principalia are large curved diactins to 6.2 cm long by 214 μm width. They are accompanied by diactin comitalia and intermedial oxyhexactins. Three classes of dermalia are present. Large sword hexactins in the parietal ridges and marginal collar have tangential rays 130-*185*-244 μm, distal rays 171-*512*-788 μm, and proximal rays 301-*852*-1765 μm in length. Smaller dermals have tangential rays 131-*261*-391 μm, distal rays 64-*125*-233 μm but proximal rays either short 47-*144*-346 μm, or

long 352-*492*-683 μm. Gastralia are the usual pentactins (not measured). Mesoscleres consist of thick-rayed hexactins and pentactins covering sieve plate beams and spiny intermedial oxyhexactins with rays 104-*158*-192 μm in length, the latter uncommon.

Microscleres: Oxystauraster with three (rarely five) terminals are the most abundant microsclere, 73-*94*-117 μm in diameter. Variants occur as pentasters (6%), triasters (<1%), hexasters (<1%), and octasters (<1%). Floricomes bearing eight terminals per primary are common in dermal structures, 115-*131*-147 μm in diameter. Terminal expansions carry 3-*6*-*7*-8 recurved claws (Fig. 12). The presence of graphiocomes verified by their characteristic centra, 30-*35*-43 μm in diameter, and abundant raphide terminals, 167-*196*-242 μm in length.

Remarks

The specimen generally agrees with the descriptions of *Regadrella okinoseana* from Sagami Bay, Japan, by Ijima (1896, 1901) and from New Caledonia by Lévi & Lévi (1982), but differs in a few features. The principalia of the present specimen attain much larger dimensions than those of either of the other two known localities, but this is explained by the larger size and presumably greater age of the South Australian specimen – the largest from Sagami Bay was 42 cm and from New Caledonia 29 cm in total length for intact individuals. The floricomes of the present specimen are larger (mean 131 *vs* 98-107 μm at Sagami Bay and 90 μm at New Caledonia) and carry more terminal spines (usually 6-7 *vs* 2-3 at Sagami Bay and undescribed at New Caledonia). The spiny mesohexasters are larger than the Japan specimens (104-192 *vs* 55-150 μm ray length), but of the same mean size as those from New Caledonia. These differences are accepted as within the range of geographic variation of a species and are not considered adequate for recognition of even varietal status.

Only three species of *Regadrella* contain oxystauraster as characteristic microscleres, *R. okinoseana*, *R. decora* Schulze, 1900, from near Cape Comorin, Indian Ocean, and *R. cylindrica* Ijima, 1927, from north of Celebes. Review of Schulze's description of *R. decora* suggests that his recognition of this as distinct from *R. okinoseana* was based upon Ijima's poor original description and Schulze's misinterpretation of same. The only differences between these appear to be the lack of oxyhexasters and more angular nature of principalia in *R. decora*, both of which appear to be of dubious value since the oxyhexasters are rare and the principalia are clearly curved in *R. okinoseana*. The distinction between *R. okinoseana* and *R. cylindrica* is equally tenuous, based again on the absence of oxyhexasters, the lack of spiny microxyhexasters, and the greater size of oxystauraster in the latter. The first two differences are trivial since 'absence' of these uncommon spicule classes depends upon search effort, and the third distinction is slight, based on nonquantitative data, and is not deserving of even varietal importance, particularly with the greater overlap provided by the South Australian specimen. Both original authors were insecure in their assessment of the validity of the two later species, and recent authors (Lévi & Lévi 1982; Salomon 1990) have supported amalgamation of the stauractine-bearing *Regadrella* species. Synonymy of *R. decora* and *R. cylindrica* with *R. okinoseana* is supported by the data from the new specimen, and is here formally proposed.

Sieve plate fusion, present in this specimen, is extremely rare in lyssacine hexactinellids, and is apparently restricted to individuals of extreme age. It has never been documented by illustration. Chimmo (1878: 10) aluded to fusion of the sieve plate in *Euplectella aspergillum* Owen, without convincing microscopic evidence. Ijima (1902b: 4), an authority with extensive observational experience, provided a more convincing statement for *Corbitella speciosa* (Quoy & Gaimard). Tabachnick (1990: 169) reported synapticular fusion in the sieve plate of the 230 mm long holotype of *Regadrella peru* Tabachnick, but provided no photographic record. No other observation of sieve plate fusion is known in recent lyssacinosans. The rarity of extensive sieve plate fusion is appreciated since it presents a barrier to alteration of the central meshes. Potential for growth is retained by the lack of fusion at the marginal junction with the body wall. Synapticular fusion does enhance fossilization in these members of the lyssacine hexactinosans (Salomon 1990), a group otherwise poorly represented in the fossil record.

Distribution

Sagami Bay, Japan, 358-832 m depth; New Caledonia 390-505 m depth; SW of Cape Comorin, Indian Ocean, 787 m depth; N of Celebes, 1 165-1 264 m depth; Great Australian Bight, 999-1 110 m depth.

Acknowledgments

I thank Shane Parker of the South Australian Museum for instigating this study, and providing access to the SAM specimens. The manuscript was greatly improved by comments supplied by Prof. P. A. Bergquist, Dr John N. A. Hooper and Shane Parker. This work was supported by an operating grant from the Natural Sciences and Engineering Research Council of Canada.

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NEW SPECIES OF ORIBATULIDAE (ACARIDA: CRYPTOSTIGMATA: PLANOFISSURAE) FROM SOUTH AUSTRALIAN SOILS, WITH A REVIEW OF SUBFAMILIES AND AUSTRALIAN RECORDS

D. C. LEE

LEE, D. C., 1992. New species of Oribatulidae (Acarida: Cryptostigmata: Planofissurae) from South Australian soils, with a review of subfamilies and Australian records. *Rec. S. Aust. Mus.* 26(1): 37–49.

Oribatulid mites from Australian soils are considered with comments on the subfamilies. Three new species, a new genus and a new species record are established for two subfamilies in South Australia as follows: Oribatulinae – *Oribatula runcinata* sp. nov., *Zygoribatula cycloporosa* sp. nov., *Z. magna* Ramsay; Pseudoppiinae – *Ausoribula quagesetosa* gen. nov., sp. nov. Of the nine florally diverse South Australian sites sampled, the new species and records are from only three sites with either a semi-arid, mallee-heath or pasture habitat. A key is provided for all six oribatulid species known from Australia. *Oribatula caudata* Berlese, 1910 is newly regarded as a synonym of *Sellnickia caudata* (Michael, 1908).

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This is a further part of an ongoing study of sarcoptiform mites in South Australian soils, sampled from nine florally diverse sites, and for which an introduction to the relevant work on the advanced oribate mites (Planofissurae) has been published (Lee 1987). The classification of the Oribatulidae followed was initially that of Balogh & Balogh (1984). This was changed after the description of species of a number of oripodoid genera from or relevant to the Australian fauna (Lee 1987; Lee & Birchby 1989, 1991a, 1991b) led to the higher classification of the Oripodoidea, and so the included Oribatulidae, being modified (Lee 1991). The present paper outlines and adds to these changes to the oribatulid classification and also deals with three genera, from two subfamilies, from which three new species are described. A key is provided to distinguish all six oribatulid species known from Australia, completing the consideration of the Oribatulidae within this study.

The mites studied have either been deposited in the South Australian Museum (SAMA), the Field Museum, Chicago (FMNH), the Natural History Museum, London (BMNH), or the New Zealand Arthropod Collection, D.S.I.R. Auckland (NZAC), whilst the holotype of *Zygoribatula longiporosa* Hammer, 1953 has been returned to the Queensland Museum (QM). The morphological notational system follows Lee (1987), the somal chaetotaxy of which is summarised in Figs 1 and 2, with the total setae present in each file (*e.g.* 6Z) indicated by number coming first, whilst a particular seta (*e.g.* Z6) would have the number last. The abbreviations for zoogeographical regions follow Lee (1970, fig. 427). The descriptions of eggs refer to them whilst still within the female soma. All material was examined using a Normarski interference contrast device. Measurements are in micrometres (μm) and were made using an eyepiece micrometer at ×250 magnification.

SYSTEMATICS

Family ORIBATULIDAE Thor

Oribatulidae Thor, 1929: 184
Oribatulidae: Grandjean, 1954: 440
Oribatulidae: Coetzer, 1968: 15
Oribatulidae: Balogh & Balogh, 1984: 270

Nominotype: *Oribatula* Berlese, 1896

Diagnosis

Oripodoidea. Hysterönotal foramina multiporose. Dorsosejugal furrow present or absent. Lamella (between setae *z*1-*z*2) and translamella (between setae *z*1-*z*1), if present, either lamellate, costate or lineate. Other proteronotal ridges (sublamella, prelamella, tutorium or subtutorium) costate or lineate. Hysteronotum without pteromorph, although may have humeral process, and limbus usually inconspicuous. Ventrosejugal apodeme either complete or partial with mid-sternal gap. Preanal sclerite with breadth of lever half or less that of refractile cup-shaped caput. Femur I, and usually II, with medium-size stalk (length about 2× pedestal diameter), so that caput well separated from pedestal. Femur I and II each with 5 setae, seta *v*2 present. Tarsi I and II broad proximally (greater than 0.75× broadest part). Pretarsus with three claws. Larva with seta on anal shield, and solenidion on palp tarsus does not form 'corne double' with dorsal plasmic seta.

Remarks

The Oribatulidae were restricted when some genera were removed to establish Scheloribatidae (Grandjean, 1933), but this was not generally accepted until a revision of the Oripodoidea (as Oribatuloidea) by Balogh & Balogh (1984), where Scheloribatidae was

mistakenly referred to as a new family. In Balogh & Balogh's revision, the Oribatulidae were subdivided into four subfamilies, mainly on the basis of the number of genital setae. A subfamily that they ignored, Pseudoppiinae Mahunka, 1975, has since been redefined by Lee (1987) and, with a new subfamily, Fovoribatulinae Lee & Birchby, 1991a, extended the Oribatulidae to six subfamilies. Four of these subfamilies (Capilloppiinae, Crassoribatulinae, Fovoribatulinae and Sellnickiinae) have since been excluded from the Oribatulidae and they are considered briefly here.

The Fovoribatulinae Lee & Birchby, 1991a, when established, included new genera, *Brassiella* Balogh, 1970 (*ex* Fenicheliidae), *Reticuloppia* Balogh & Mahunka, 1966b (*ex* Oribatulinae) and *Romanobates* Feider, Vasiliu & Calugar, 1970 (*ex* Capilloppiinae). The subfamily was recognised by the absence of a seta (*av*2) on femur II. Later, this character state was considered as diagnostic of the primitive Crassoribatulid-complex (Lee 1991), many members of which are similar to the oribatulid species. Both Fovoribatulinae and Crassoribatulinae Balogh & Balogh, 1984 (ex Oribatulidae) were grouped in this Crassoribatulid-complex.

Both Sellnickiinae Grandjean, 1960 (mistakenly referred to as a new subfamily by Balogh & Balogh, 1984) and Capilloppiinae Balogh & Balogh, 1984 were excluded from the Oribatulidae to be included in either the Sellnickiid-complex or the Capilloppiidae (Mochlozetid-complex) by Lee (1991). This was mainly based on the shape of their preanal sclerites, but it has since been established (see following remarks) that the Capilloppiidae have a leg chaetotaxy and preanal sclerite as for members of the Crassoribatulid-complex and they are placed as a subfamily within the Crassoribatulidae.

The examination of the types of further oribatulid-like taxa, since the above changes were made (Lee 1991), has established that some of them lack seta *v*2 on femur II and they are, therefore, also here grouped in the Crassoribatulidae-complex. For these taxa, the setation of femur I and II is as follows: *Nesozetes rostropterus* Hammer, 1971 – femur I 1,2/1,0, femur II 1,2/1,0; *Capilloppia capillata* Balogh & Mahunka, 1966a – femur I 1,2/1,0, femur II, 1,2/1,0; *Lunoribatula polygonata* Mahunka, 1982 – femur I 0,2/1,0, femur II 0,2/1,0. Also the preanal sclerites of the types of *Capilloppia capillata* have a narrow lever and a refractile cup-shaped caput. Therefore, the new placings of these taxa, which have been grouped within or near to the Oribatulidae, are now within the Crassoribatulid-complex adding two subfamilies to that complex as follows: the Nesozetinae Balogh & Balogh, 1984 are grouped in the Lamellareidae Balogh, 1972 and the Capilloppiinae Balogh & Balogh, 1984, including *Lunoribatula*, are in the Crassoribatulidae Balogh & Balogh, 1984.

Key To Australian Oribatulid Species (Adults)

1 – Ventrosejugal apodemes continuous across midsternal line ..... Oribatulinae 2
– Ventrosejugal apodemes do not merge across midsternal line ..... Pseudoppiinae 5
2 – Translamella absent .. *Oribatula runcinata* sp. nov.
– Translamella present ..... *Zygoribatula* 3
3 – Lamella and translamella broad, cuspis large (length about 5× diameter of setal base to *z*1). Behind interlamella seta (*j*2), ridge runs back to dorsosejugal furrow. First hysteronotal foramina (*F*3) oval (length 2× breadth), shorter than seta *Z*2 ..... *Zygoribatula magna* Ramsay
– Lamella and translamella narrow, cuspis small (length about 2× diameter of setal base to *z*1) 4
4 – Behind interlamella seta (*j*2), ridge runs laterally to sensory seta (*z*2). First hysteronotal foramina (*F*3) spherical (length subequal to breadth). Head of sensory seta (*z*2) globular ..... *Zygoribatula cycloporosa* sp. nov.
– Interlamellar seta (*j*2) without associated ridges. First hysteronotal foramina (*F*3) elongate (length about 10× breadth). Head of sensory seta (*z*2) pyriform ..... *Zygoribatula longiporosa* Hammer
5 – Hysteronotum with 15 pairs of setae (6*J*, 6*Z*, 3*S*). Genital shield with two pairs of setae (2*JZg*) ..... *Constrictobates lineolatus* Balogh & Mahunka
– Hysteronotum with 10 pairs of setae (2*J*, 6*Z*, 2*S*). Genital shield with four pairs of setae (4*JZg*) ..... *Ausoribula quagesetosa* sp. nov.

Subfamily ORIBATULINAE Thor

Diagnosis

Oribatulidae. Ventrosejugal apodemes continuous across midsternal line. Hysteronotum oval, sometimes with humeral process, usually with 14 pairs of setae (exceptions: 10 pairs on *Paraphauloppia* and *Jornadia*, 12 or 13 pairs on some *Eporibatula*, *Oribatula* and *Zygoribatula* species), sejugal furrow not extending anterior to bothridium (around seta *z*2), always present across mid-line. Four pairs of multiporose hysteronotal foramina usually present (exception: three pairs on *Paraphauloppia triforamina*). Genital shield usually with four pairs of setae (exception: five pairs on *Jornadia*). Legs long and slim.

Remarks

The Oribatulinae included 14 genera in the classification of Balogh & Balogh (1984). One of these genera, *Reticuloppia* Balogh & Mahunka, 1966b, has been transferred (Lee & Birchby 1991a) to Fovoribatulinae (Crassoribatulidae), whilst a number of genera are here grouped in Pseudoppiinae (see following text). This leaves only the following eight genera, of which the majority are cosmopolitan, in the Oribatulinae: *Eporibatula* Sellnick, 1928; *Jornadia* Wallwork & Weems, 1984; *Lucoppia* Berlese, 1908; *Oribatula* Berlese, 1896; *Paraphauloppia* Hammer,

1967; *Phauloppia* Berlese, 1908; *Spinoppia* Higgins & Woolley, 1966; *Zygoribatula* Berlese, 1916.

Other than the South Australian material collected in this study only the cosmopolitan *Zygoribatula* has been recorded from Australia (Hammer 1953). *Paraphauloppia*, previously known only from New Zealand and South America, has been collected in this study (Lee & Birchby 1991b). The current paper includes the first record of the cosmopolitan *Oribatula* from Australia.

Genus *Oribatula* Berlese

Oribatula Berlese, 1896: LXXIX,12. Type-species (original designation): '*Oribatula tibialis*' (=*Notaspis tibialis* Nicolet, 1855; Berlese, 1895: LXXVII,5).
Oribatula: Hammen, 1952: 80.
Oribatula: Travé, 1961: 313.
Oribatula: Coetzer, 1968: 55.

Type-species: *Oribatula tibialis* (Nicolet, 1855)

Diagnosis

Oribatulinae. Twelve, thirteen or fourteen pairs of short, smooth or weakly ciliate hysteronotal setae. Humeral setae (*Zl*, *Sl*) similar in shape and size to other hysteronotal setae (rarely *Zl* stouter, but still subequal in length). Proteronotum without translamella, lamella at least lamellate anteriorly (never just costate or lineate), in subparallel pair, medium size or long, distance between lamellar seta *zl* and dorsosejugal furrow greater than 1.5× distance between interlamellar seta *j2* and bothridium of sensory seta *z2*. Genital shield with four pairs of setae.

Distribution

Regarded as possibly cosmopolitan, but all records before this paper appear to be from only the Holarctic or Ethiopian region. Both saxicolous and arboreal on epiphytes (Travé 1961), in Europe found on moss on northern slopes of mountains, and not very sensitive to drought (Hammen 1952), also found in marshes and pasture sod (Krantz 1978). This single record from Australia is from the semi-arid region.

Remarks

Oribatula is very similar to some other oribatulid genera. It only differs from *Zygoribatula* in that it lacks a translamella as commented on later in the 'Remarks' on that genus. It is also very like *Phauloppia*, which differs in having a lineate lamella, seta *zl* closer to *j2* than *j1* and seta *Zl* closer to *Sl* than *J2*.

Oribatula caudata Berlese, 1910 from *Citrus deliciosa*, New South Wales, is here combined with *Sellnickia* and is also newly regarded as a synonym of its senior homonym, *Sellnickia caudata* (Michael, 1908). *S. caudata* was originally described from New Zealand, but was redescribed in detail by Grandjean (1958) from the leaves of lemon trees in Queensland. The similarity in appearance, including the presence of a rather long conical posterior process on the hysteronotum of an *Oribatula*-like mite, is considered sufficient to group *Oribatula caudata* in *Sellnickia*.

Oribatula includes the following 15 species and one subspecies (note – many species with 10 pairs of hysteronotal setae were transferred to *Paraphauloppia* by Coetzer, 1968): *O. acuminata* Wallwork, 1964; *O. exsudans* Travé, 1961; *O. florens* Berlese, 1908; *O. incompleta* Mahunka, 1987; *O. interrupta* (Willmann, 1939); *O. interrupta major* (Mihelcic, 1963); *O. pallida* Banks, 1906; *O. pannonica* Willmann, 1949 (see Travé, 1961); *O. parisi* Travé, 1961; *O. sakamorii* Aoki, 1970; *O. saxicola* (Kunst, 1959); *O. tibialis* Nicolet, 1855; *O. torrijosi* Subias, Ruiz & Kahwash, 1990; *O. variabilis* Berlese, 1908; *O. venusta* Berlese, 1908; *O. vera* (Bulanova-Zachvatkina, 1967).

Oribatula runcinata sp. nov.

(Figs 1-3)

Female

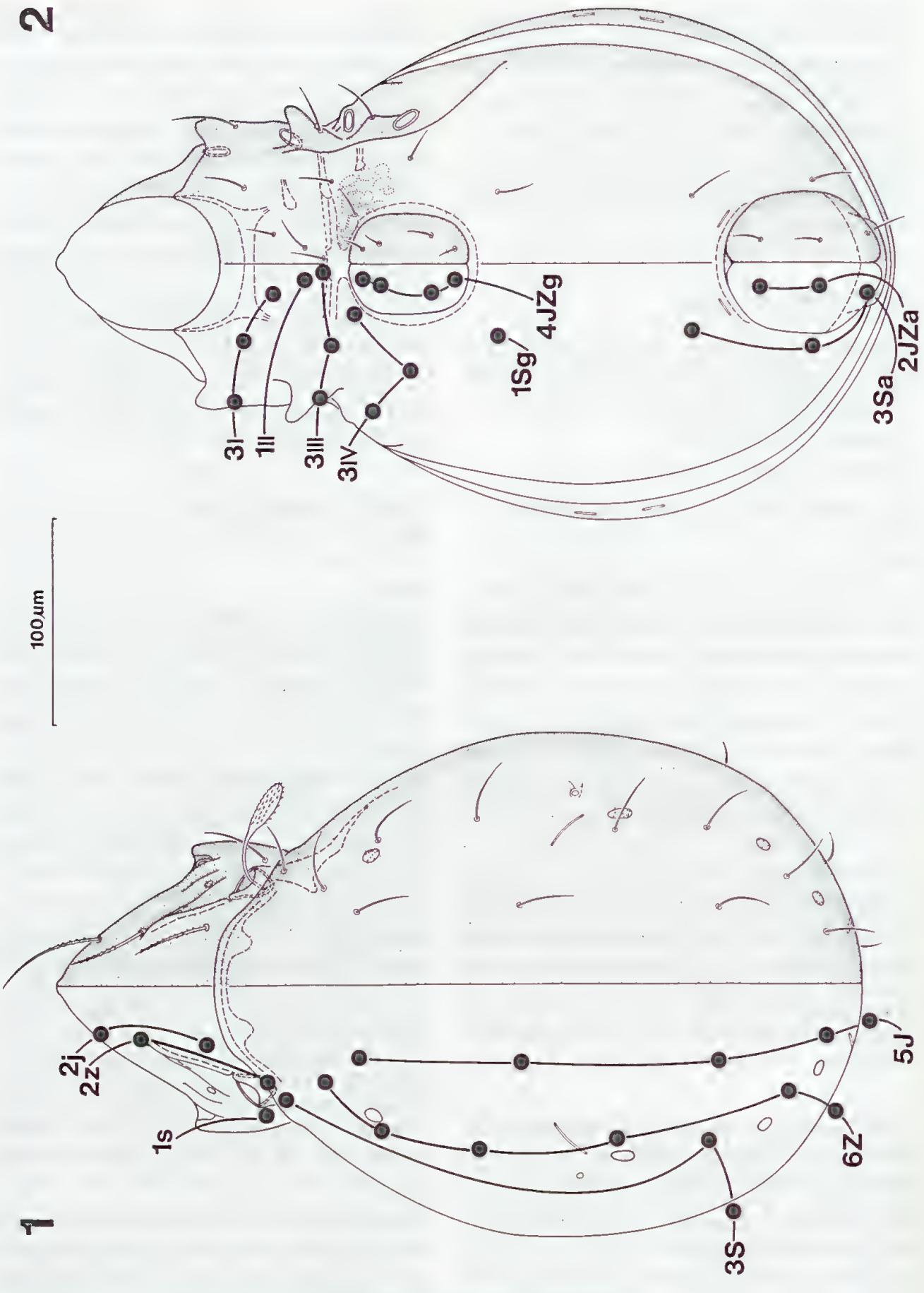
Dorsal profile of hysteronotum ovoid, mid-brown, surface glabrous, without reliculations. Coxite area with faint reticulations. Idiosomal length 397 (n = 15, 357-437). Leg lengths (femur-tarsus for idiosomal length 400): I-222, II-182, III-172, IV-220. Tibial maximum heights (for 400): I-20.5, II-15.5, III-13, IV-14.

Proteronotum with slim lamella, mainly costate, lamellate anteriorly, but not bearing seta *zl* (lies on flat proteronotal surface), and costate sublamella. Setae *j1*, *j2* and *zl* stout, and noticeably ciliate, *j1* longest. Sensory seta (*z2*) clavate, exposed stalk subequal in length to head covered with fine cilia.

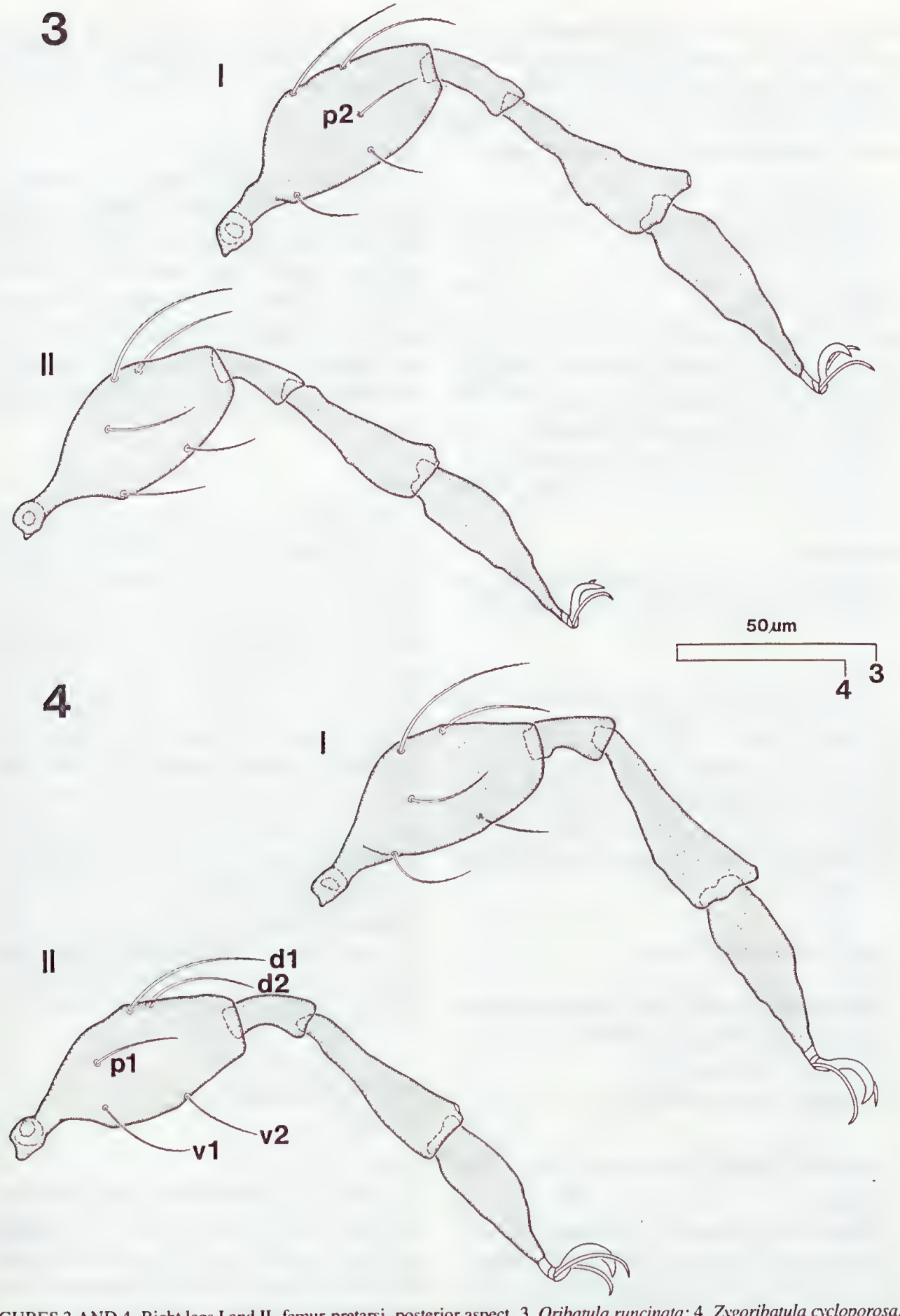
Hysteronotal setae short, fine, setose and subequal in length. Multiporose foramina small, *F3* length less than 0.33× distance between setae *Zl*-*Z2*, anterior two pairs (*F3*, *F4*) larger than posterior pairs (*F5*, *F6*), all four pairs round or weakly oval. Slit shaped pore *hf3* sloping outwards towards posterior.

Podosternum with circumpedal ridge merged with rest of subpedal ridge, distinct from and ventral to discidium and pedotectum II, absent below pedotectum I. Discidium forms costate ridge. Setae vary in length, lateral setae (*I3*, *III3*, *IV3*) similar to hysteronotal setae, other coxite setae smaller, smallest setae on genital shields.

Opisthosternum with outer file (*Sa*) of setae longer than coxite setae and setae on anal shield (*JZa*) subequal in length to smallest coxite setae. Slit-like pore *Saf* nearly transverse, more than 45° from longitudinal axis. Eggs subcylindrical with convex ends, 181 × 90 (mean of 7 horizontally aligned eggs, 46% of mean female length), smooth exochorion. Number of eggs



FIGURES 1 AND 2. *Oribatula runcinata*, female soma. 1, notum; 2, idiosternum



FIGURES 3 AND 4. Right legs I and II, femur-pretarsi, posterior aspect. 3, *Oribatula runcinata;* 4, *Zygoribatula cycloporosa.* All setae on femurs I and II illustrated, *d* = dorsal, *p* = posterior, *v* = ventral.

in female (number of females) as follows: none (2), one (1), two (4), three (5), four (2), six (1).

Legs long (mean femur-tarsus: 50% soma), slim (mean maximum tibial height: 26% of mean length). All femora and trochanters III and IV with dorsal adaxial porose areas and vertical adaxial ridges.

Male

As female except soma smaller, idiosomal length 359 (n = 23, 332-380).

Material examined

Holotype: ♀ (N19901033), soil, litter, moss and other low growth plants under bladder saltbush (*Atriplex vesicaria*) amongst sparse false sandalwood (*Myoporum platycarpum*), Koonamore Vegetation Reserve (32°07′S, 139°21′E), 27.vi.1974.

Paratypes: 11 ♀♀ (N19901034-N19901044); 17 ♂♂ (N19901045-N19901061); 1 ♀, 2 ♂♂ BMNH; 1 ♀, 2 ♂♂ FMNH; 1 ♀, 2 ♂♂ NZAC; same data as holotype.

Distribution

Australia (Aa), South Australia. Semi-arid low shrubland (Koonamore Vegetation Reserve), Lake Eyre Basin, 15 ♀♀, 23♂♂/ 5 of 8 × 25 cm^2.

Remarks

The specific name *runcinata* is derived from the Latin 'runcinare' to 'smooth' and refers to the unsculptured notal surface. The slim lamellae distinguish *O. runcinata* from other species of *Oribatula*, and although *O. pannonica* Willmann, 1949 also has slim lamellae they are extensive enough to carry seta zl. The large sensory seta (z2) also distinguishes it, *O. vera* (Bulanova-Zachvatkina, 1967) having the next largest seta z2.

Genus *Zygoribatula* Berlese

Zygoribatula Berlese, 1916: 317. Type-species (original designation): *'Oribates connexus* Berl.'.
Neoribatula Ewing, 1917: 128.
Zygoribatula: Travé, 1961: 328.
Zygoribatula: Coetzer, 1968: 92.

Type-species: *Zygoribatula connexa* (Berlese, 1904)

Diagnosis

Oribatulinae. Thirteen or fourteen pairs of short to medium, smooth or weakly ciliate hysteronotal setae. Humeral setae (Zl, Sl) similar in shape and size to other hysteronotal setae (rarely Zl stouter and more ciliate, but still subequal in length or smaller). Proteronotum with lamellate translamella and lamella, subparallel pair of lamellae, medium size to long, distance between lamellar seta (zl) and dorsosejugal furrow greater than 1.5× distance between interlamellar seta *j*2 and bothridium of sensory seta *z*2. Genital shield with four pairs of setae.

Distribution

Cosmopolitan. Both saxicolous and arboreal, in moss, or on sap or bark, also hemiedaphic in many different types of soil from sand to clay, with or without humus and even in the intertidal zone. Three species are now known from Australia. *Zygoribatula longiporosa* Hammer, 1953 was recorded from pasture in southern Queensland, *Z. magna* Ramsay, 1966, originally described from pasture near Wellington, New Zealand, is now recorded from pasture near Adelaide, South Australia, and *Z. cycloporosa* sp. nov. was collected at the Mallee-heath site under *Banksia* shrubs.

Remarks

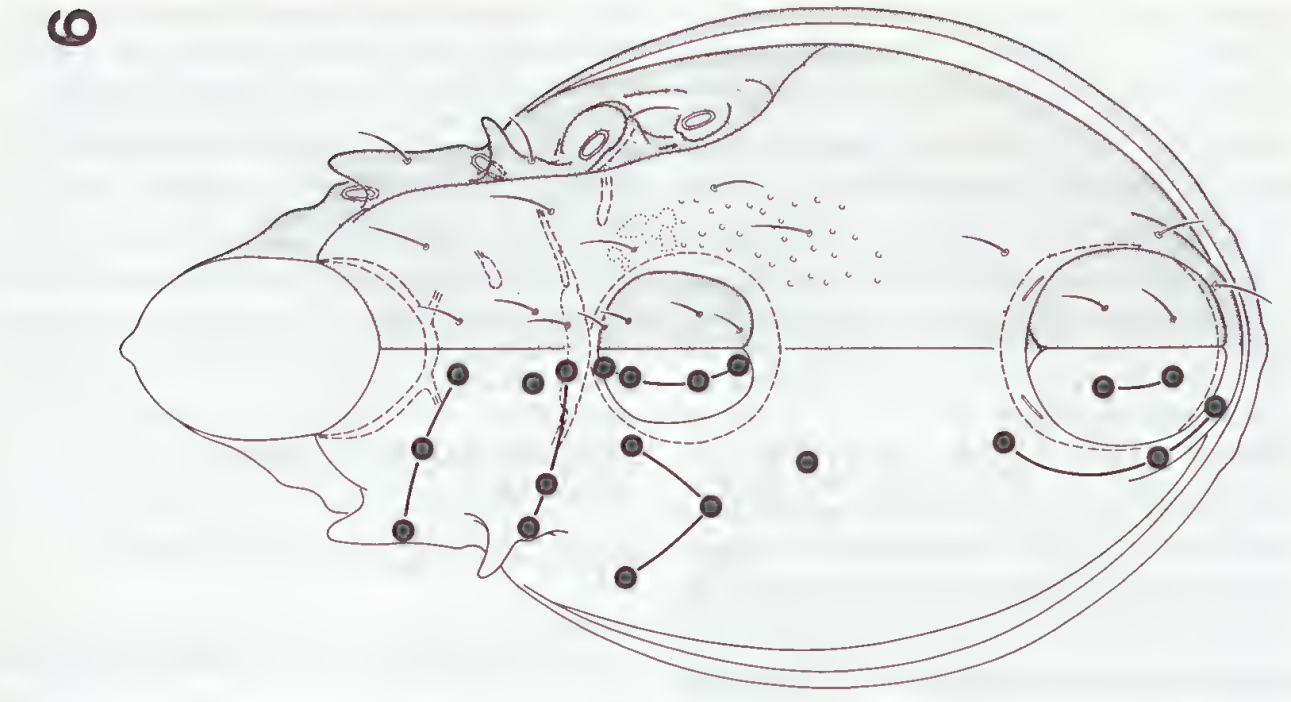
Zygoribatula is very similar to *Oribatula*, as discussed by Travé (1961), who decided to retain the genus 'pour des raisons de commodité', implying that it may not be valid. The only character distinguishing *Zygoribatula* from *Oribatula* is the presence of a complete lamellate translamella between setae zl-zl and this may be discontinuous in some specimens of a species (Luxton, 1987). *Zygoribatula* is much more species-rich than *Oribatula*. Fritz (1982) lists 85 species, but two of these (*Z. interrupta* and *Z. saxicola*) are here grouped in *Oribatula* as by Travé (1961). *Zygoribatula lenticulata* Minguez & Subias, 1986, because of its similarity to *Romanobates* in the Crassoribatulidae, had the chaetotaxy of two of its male paratypes examined and for femur I it was 1,2/2,1 and for femur II it was 1,2/2,1, as for all oribatulids, and not fewer setae as for Crassoribatulidae. *Zygoribatula dactilaris* Subias, Ruiz & Kahwash, 1990 is newly combined with *Phauloppiella*, as commented on in the following remarks on Pseudoppiinae. A further three species are included in *Zygoribatula* as follows: *Z. baloghi* Mahunka, 1986, *Z. endroedyi* Mahunka, 1986 and *Z. knighti* Luxton, 1987.

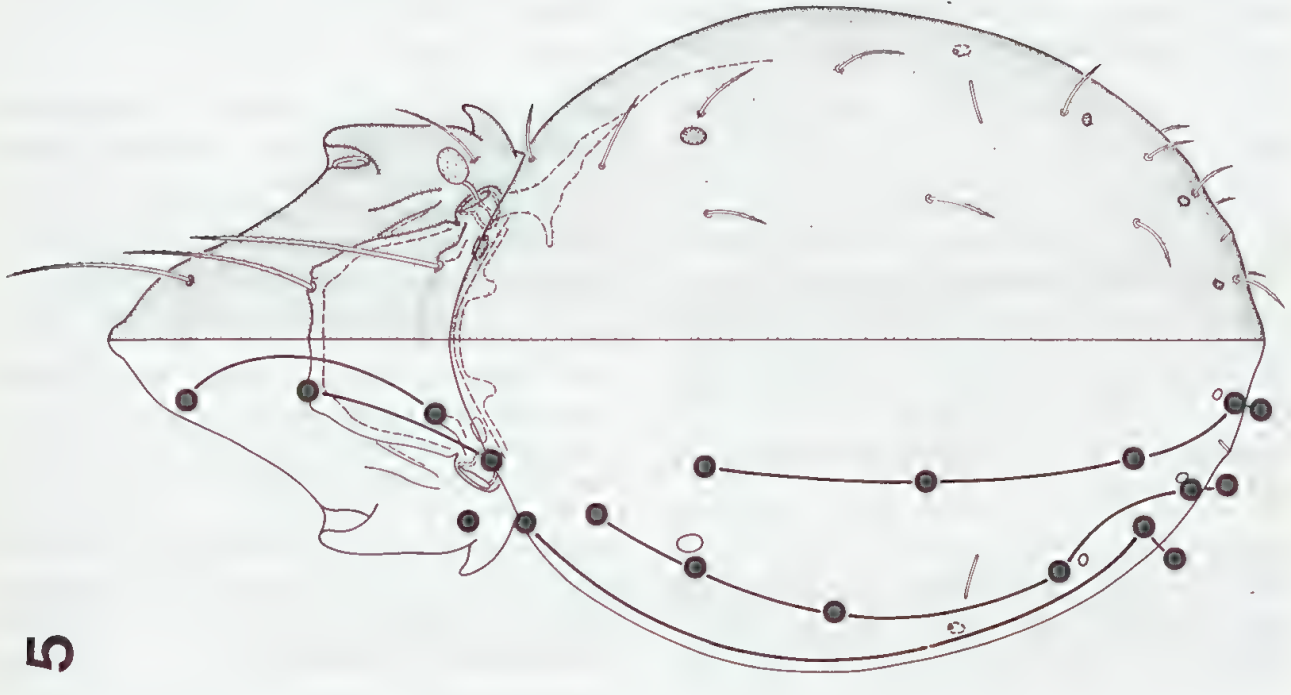
Zygoribatula cycloporosa sp. nov.
(Figs 4-6)

Female

Dorsal profile of hysteronotum ovoid, light-brown, surface sparsely punctate. Coxite area with reticulations. Idiosomal length 401 (n = 3, 388-409). Leg lengths (femur-tarsus for idiosomal length 388): I-244, II-208, III-203, IV-249. Tibial maximum heights (for 388): I-23, II-18, III- 18, IV-18.

Proteronotum with lamellate lamella and translamella, and costate sublamella and costate ridge between setae *j*2-*z*2. Setae *j*1, *j*2 and zl long, stout, and





FIGURES 5 AND 6. *Zygoribatula cycloporosa*, female soma. 5, notum; 6, idiosternum. For setal notation see Figs 1 and 2.

noticeably ciliate, *j*2 longest. Sensory seta (*z*2) medium size (length 0.33 × distance between setae *z*1-*z*2), capitate, exposed stalk subequal in length to head covered with fine cilia.

Hysteronotal setae short, stout, setose (weakly ciliate) and subequal in length. Multiporose foramina small, diameter of *F*3 less than 0.33 × distance between setae *Z*1-*Z*2, anterior pair (*F*3) conspicuously larger than posterior pairs (*F*4, *F*5, *F*6), all four pairs round. On right side of one female, foramina *F*5 and *F*6 replaced by single pair in intermediate position. Slit shaped pore *hf*3 nearly transverse, sloping acutely inwards towards posterior.

Podosternum with circumpedal ridge merged with rest of subpedal ridge, distinct from and ventral to discidium and pedotectum, present (may be faint) below pedotectum I. Discidium forms semicircular costate ridge around posterior margin of acetabulum for leg III. Setae slim, setose, longer if positioned closer to lateral margin. Smallest setae on genital shields. On right side of one female, five genital setae.

Opisthosternum with setae in outer (*Sa*) and inner (*JZa*) files subequal in length. Slit-like pore *Saf* nearly transverse, more than 45° from longitudinal axis. Eggs subcylindrical with convex ends, 168 × 74 (mean of 4 horizontally aligned eggs, 42% of mean somal length), smooth exochorion. Number of eggs in female (number of females) as follows: one (1), two (1), four (1).

Legs long (mean femur-tarsus: 57% soma), slim (mean maximum tibial height: 30% of mean length). All femora and trochanters III and IV with dorsal adaxial porose areas and, on femora III and IV, strong vertical ridges on adaxial surface, ventral to porose areas.

Male

Unknown.

Material examined

Holotype: ♀ (N19901280), sand, litter, under banksia shrubs (*Banksia ornata*) amongst other sclerophyllous shrubs and sparse brown stringybark mallee (*Eucalyptus baxteri*), Tamboore Homestead (35°57′S, 140°29′E), 4.viii.1974.

Paratypes: 2 ♀♀ (N19901281, N19901282) same data as holotype.

Distribution

Australia (Aa), South Australia. Mallee-heath, tall open shrubland (Tamboore Homestead, near Mt Rescue Conservation Park), Murray-Darling basin, 3 ♀♀/ 1 of 8 × 25 cm^2.

Remarks

The prefix of the specific name *cycloporosa* is derived from the Greek 'kyklos' for 'circle' and refers to the hysteronotal multiporose foramina, which are circular in outline. The only other species which have small, circular hysteronotal foramina and mainly costate lamellae and translamella (with limited lamellate parts and no distinct cuspis at apex of lamella) are *Z. frisiae* (Oudemans, 1900) from Netherlands, *Z. knighti* Luxton, 1987 from England and *Z. tenuelamellata* Miheleie, 1956 from Spain. *O. cycloporosa* is regarded as the most similar to *Z. knighti* because of the presence of a costate ridge between setae *j*2 and *z*2. It differs from all three species in having long interlamellar setae (*j*2) and an almost globular caput on setae *z*2.

Zygoribatula longiporosa Hammer
(No figures)

Zygoribatula longiporosa Hammer, 1953: 236.

Female

Legs: Chaetotaxy of femur I 0,2/2,1; femur II 0,2/2,1.

Material examined

Syntypes, two females (W1854, W3569), pastures, lot 52-56 29, Yeerongpilly, Queensland, 14th May, 1952, F. H. S. Roberts.

Remarks

Zygoribatula longiporosa is the only species of Oribatulidae (as delineated here) recorded from Australia previous to this study. It was collected in large numbers from calf pastures in Queensland and examined for cysticercoids of the tapeworm *Moniezia benedeni*, between 1.8% and 5.7% being infested depending on the pasture sampled (Roberts, 1953). The types have been examined to establish the leg chaetotaxy, which has proved to be as found in the Oribatulidae and not reduced by at least the absence of a ventral seta on femur II as for the Fovoribatulinae. Proposals have been made that *Z. longiporosa* and *Z. tadrosi* Popp, 1960 from Egypt are synonymous with *Z. undulata* Berlese, 1916 from Italy (Pérez-Iñigo, 1974) and that *Z. longiporosa* is synonymous with *Z. heteroporosa* Wallwork, 1972 from California (Bhattacharya & Banerjee, 1980). These proposed synonymies are not accepted. The similarities between these species are the elongate first hysteronotal foramina (*F*3) and the narrow lamella without a cuspis. On the other hand, even on the basis of the published descriptions, there are enough differences between the species (*e.g.* the size and shape of other hysteronotal foramina and the relative sizes of proteronotal setae) to suggest that they are valid taxa.

Zygoribatula magna Ramsay, 1966
(No figures)

Female

Dorsal profile of hysteronotum ovoid, dark-brown

colour, surface covered with fine striations. Lateral punctations and areolae with strong reticulations in coxite area. Idiosomal length 507 (n = 25, 468-535). Leg lengths (femur-tarsus for idiosomal length 516): I-266, II-245, III-242, IV-307. Tibial maximum heights (for 516): I-26, II-19, III-17, IV-19. Legs long (mean femur-tarsus: 51% soma), slim (mean maximum tibial height: 28% of mean length). Chaetotaxy of femur I 0,2/2,1; femur II 0,2/2,1. Dorsal adaxial porose areas and reticulate abaxial sculpturing on all femora and trochanters III and IV, strong vertical ridges on adaxial surface, ventral to porose areas on femora III and IV. Eggs subcylindrical with convex ends, 177 × 93 (mean of 4 horizontal aligned eggs, 35% of mean somal length), smooth exochorion. Number of eggs in female (number of females, total 25) as follows: none (23), two (1), three (1).

Male

As for female except soma smaller, idiosomal length 490 (n × 25, 463-516).

Material examined

Undesignated: 116 ♀♀ (N19901062-N19901177); 102 ♂♂ (N19901178-N19901279); 5 ♀♀, 5 ♂♂ BMNH; 5 ♀♀, 5♂♂ FMNH; 5 ♀♀, 5 ♂♂ NZAC; soil, bases of cultivated grass and plantain (*Plantago lanceolata*) in pasture of sheep, Glenthorne Research Station, O'Halloran Hill (35°02′S, 138°32′E), 12.vi.1974.

Distribution

Australia (Aa), South Australia. Cultivated pasture (Glenthorne Research Station), Southern Gulfs, 131 ♀♀, 117 ♂♂/ 6 of 8 x 25 cm^2.

Remarks

Zygoribatula magna was first described from pastures near Wellington, New Zealand, where they were collected in samples with *Setobates scheloribatoides* (Ramsay, 1966) and 2-6% of the combined population of the two species were infested with tapeworm cysticercoids. No cysticercoids were found in the South Australian specimens.

Subfamily PSEUDOPPIINAE Mahunka

Pseudoppiinae Mahunka, 1975: 293
Constrictobatinae Balogh & Balogh, 1984: 280

Nominotype: *Pseudoppia* Mahunka, 1975

Diagnosis

Oribatulidae. Ventrosejugal apodemes do not meet across midsternal line. Hysteronotum pear-shaped with no humeral process, and between 10-15 pairs of setae, sejugal furrow extending anterior to bothridium (around seta *z*2), usually evanescent or absent across mid-line. Two, three or four pairs of multiporose hysteronotal foramina present. Genital shield usually with two or three pairs of setae (exceptions with 4*JZg:* *Phauloppiella* and *Ausoribula*). Legs medium length and stout.

Remarks

The Pseudoppiinae Mahunka, 1975 was established with three genera. Balogh & Balogh (1984), in their comprehensive classification of the Oripodoidea (as Oribatuloidea), ignored Pseudoppiinae, leaving two of the included genera in Oribatulinae, and mistakenly omitting altogether the third original genus, *Symphauloppia* Balogh, 1972. Lee (1987) once again recognised the Pseudoppiinae and included a further two genera, *Constrictobates* from Fenicheliidae and *Phauloppiella* from Oribatulinae. Later, Lee (1991) transferred a further five genera from either Capilloppiinae or Oribatulinae to Pseudoppiinae so that all the oribatulid genera with a gap between the ventrosejugal apodemes are included. One of these five genera, *Lunoribatula* Mahunka, 1982, has a reduced chaetotaxy on femora I and II as pointed out in previous remarks on Oribatulidae, and is now grouped in the Crassoribatulinae.

Attention is drawn here to the Liebstadiinae Balogh & Balogh, 1984, which are similar to the Pseudoppiinae, but are not regarded as allied to them, although this may change in future classifications of the Oripodoidea. The subfamily was established within the Protoribatidae, a family with multiporose foramina, a single pretarsal claw and usually with pteromorphs which are sometimes represented by only small humeral processes (as in Liebstadiinae), which is considered as representing a secondary loss of pteromorphs (Lee 1991). On the other hand, *Liebstadia* Oudemans 1906 was included in Scheloribatidae by Grandjean (1954) and still is by some acarologists (Wunderle, Beck & Woas 1990), supporting a phylogenetic model that it is primitive within the Scheloribatidae, most genera of which have sacculate hysteronotal foramina. Although the relationship of the Liebstadiinae to the Pseudoppiinae is uncertain, the adults of known taxa can easily be distinguished by the number of pretarsal claws.

The following nine genera are regarded as belonging to the cosmopolitan Pseudoppiinae: *Ausoribula* gen. nov.; *Constrictobates* Balogh & Mahunka, 1966; *Diphauloppia* Balogh & Balogh, 1984; *Gerloubia* Coetzer, 1968; *Phauloppiella* Subias, 1977; *Pseudoppia* Pérez-Iñigo, 1966; *Senoribula* Mahunka, 1975; *Subphauloppia* Hammer, 1967; *Symphauloppia* Balogh, 1972. The only previous Australian records of the Pseudoppiinae have been of *Constrictobates*, originally from Western Australia and more recently from South Australia (Lee 1987). *Ausoribula*, established here, is also from South Australia.

Genus ***Ausoribula*** gen. nov.

Type-species: *Ausoribula quagesetosa* sp. nov.

Diagnosis

Pseudoppiinae. Hysteronotum with 11 pairs of setae (*J5*, *J6*, *Z1*-*Z6*, *S1*, *S5*, *S6*) and three pairs of foramina (*F3*, *F4*, *F5*). Dorsosejugal furrow not continuous across mid-dorsal line. Lamella present, mainly costate, only lineate in region of seta *z*l. Three prosternal apodeme bases (*I*, *II* and sejugal) present. Four pairs of setae on genital shields (4*JZg*) and two pairs of setae on anal shields (2*JZa*). Legs medium length or short (order of decreasing length: I, IV, II, III), tarsi I-III about twice genu length, tarsus IV about 3× genu length.

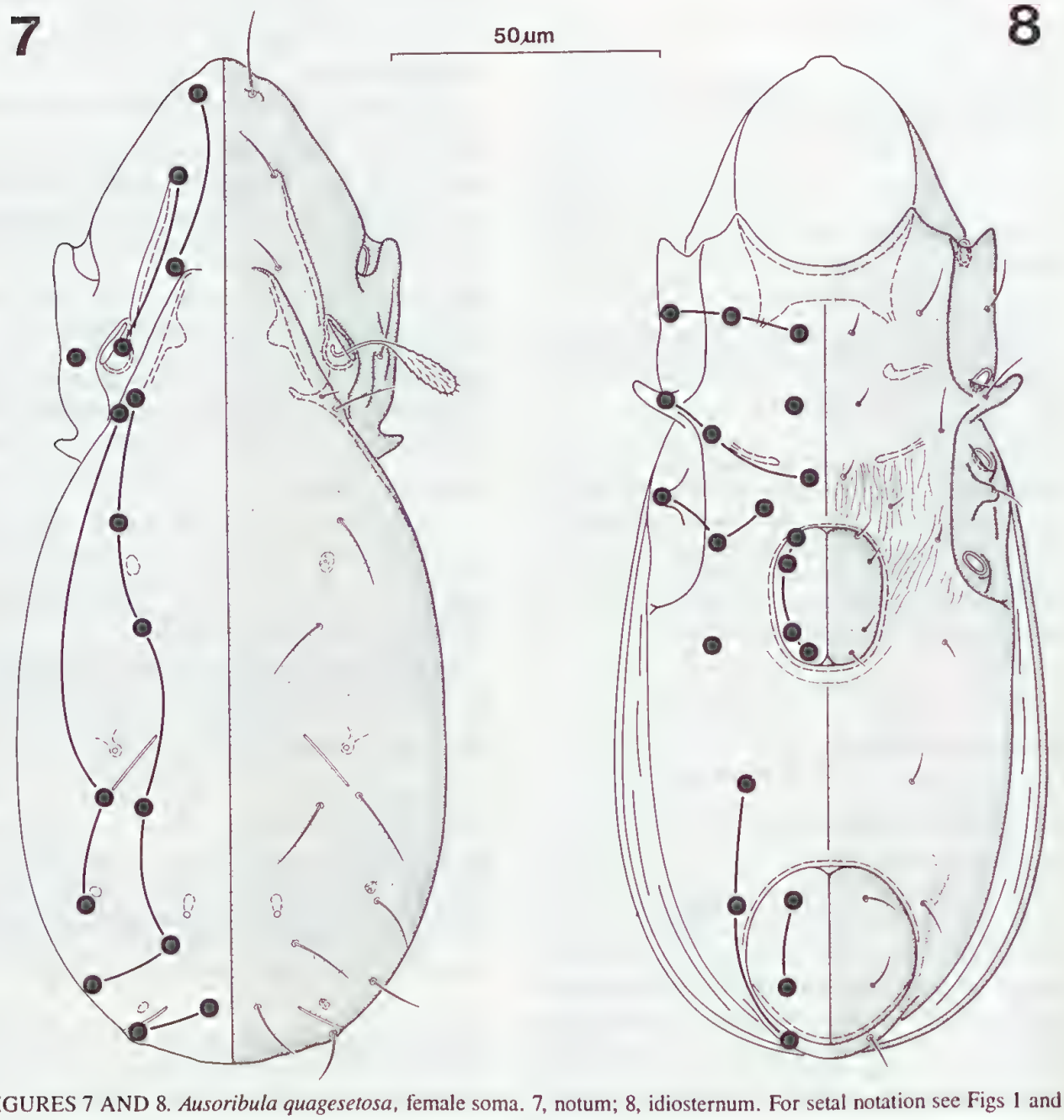
Distribution

Single species known only from South Australia.

Remarks

The prefix of *Ausoribula* refers to the genus being only known from Australia, while the rest of the name is a derivation from Oribatei (= Cryptostigmata), which Michael (1884) suggested may be derived either from the Greek words 'oros' (a mountain) and 'baino' (I go or walk) or from the proper noun 'Oribasus', Acteon's dog.

The relationships of *Ausoribula* within the Pseudoppiinae are uncertain. The recognition of pseudoppiine genera depends heavily on somal chaetotaxy, and *Ausoribula* has 14 pairs of hysteronotal setae like *Senoribula* and 4 pairs of genital setae like *Phauloppiella*. On the other hand, the presence of lamellae and only three pairs of hysteronotal foramina



FIGURES 7 AND 8. *Ausoribula quagesetosa*, female soma. 7, notum; 8, idiosternum. For setal notation see Figs 1 and 2.

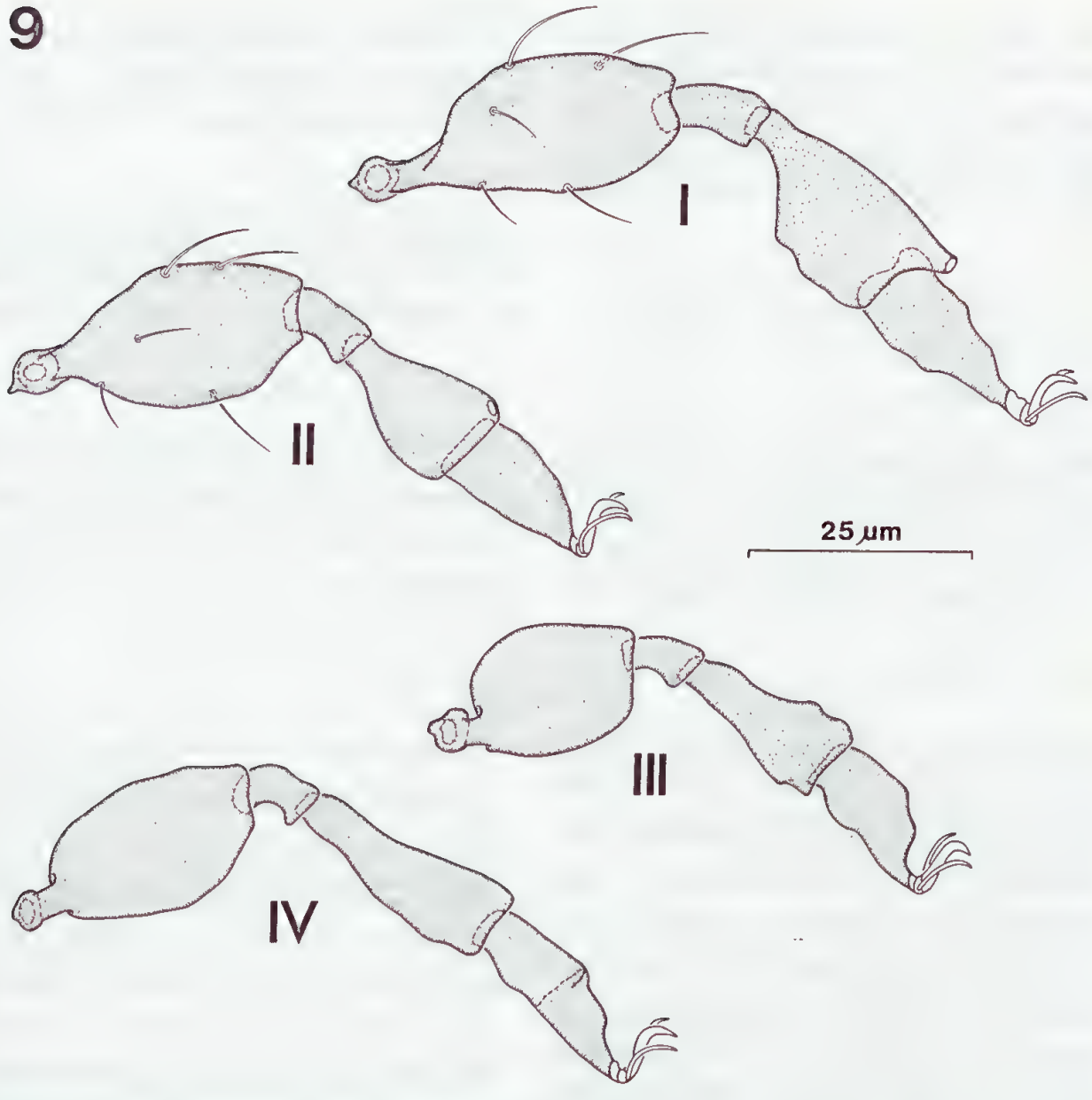


FIGURE 9. *Ausoribula quagesetosa*, female right legs I-IV, femur-pretarsi, posterior aspect. All setae on femurs I and II illustrated, *d* = dorsal, *p* = posterior, *v* = ventral.

are character states shared with the other Australian genus, *Constrictobates*, and may indicate that these two genera are closely allied.

Ausoribula quagesetosa sp. nov.
(Figs 7-9)

Female

Dorsal profile of hysteronotum nearly parallel sided, straw-colour, surface smooth. Coxite area with fine striations. Idiosomal length 183 (n = 8, 177-191). Leg lengths (femur-tarsus for idiosomal length 182): I-95, II-77, III-68, IV-85. Tibial maximum heights (for 182): I-13, II-11.5, III-10, IV-10.

Proteronotum indented posteriorly by forward protrusion of hysteronotum. Weakly lamellate lamella; sublamella, prelamella and translamella absent. Setae *j*2 and *z*1 shorter than all other notal setae except hysteronotal seta *Z*1. Sensory seta (*z*2) clavate, exposed stalk shorter than head, covered with fine cilia.

Hysteronotal seta mainly medium size, fine, setose and subequal in length, except for short seta *Z*1. Only three pairs of small, faint hysteronotal foramina. Unnamed pair of sacculate pores between setae *Z*5 and midline. Long slit shaped pore *hf*3 sloping outwards towards posterior.

Podosternum with circumpedal and sub-pedal ridge running close to base of legs, divided into two separate parts at pedotectum II. Discidium forms slim tubercle. Setae vary in length, with *I*2, *I*3, *II*3 longest and *IV*1 and *IV*2 shortest, similar to genital setae.

Opisthosternum with medium length setae compared to range in size of coxite setae. Slit-like pore *Saf* not located, although indistinct groove near genital orifice margin level with seta *Sa* may represent remnant. No eggs observed.

Legs medium length (mean femur-tarsus: 45% soma), stout (mean maximum tibial height: 51% of mean length). No dorsal porose areas, reticulate abaxial or ridged adaxial sculpturing on femora and trochanters, except that femur IV has strong vertical ridges on adaxial surface. Tarsus IV long (3× length of genu) with a vertical ridge halfway along its abaxial surface.

Male

As for female except soma smaller, idiosomal length 173 (n = 12, 167-177).

Material examined

Holotype: ♀ (N19901283), sand, litter, under banksia shrubs (*Banksia ornata*) amongst other sclerophyllous shrubs and sparse brown stringybark mallee (*Eucalyptus baxteri*), Tamboore Homestead (35°57′S, 140°29′E), 4.viii.1974.

Paratypes: 7 ♀♀ (N19901284-N19901290), 12 ♂♂ (N19901291-N19901302) same data as holotype.

Distribution

Australia (Aa), South Australia. Mallee-heath, tall open shrubland (Tamboore Homestead, near Mt Rescue Conservation Park), Murray-Darling basin, 7 ♀♀, 12 ♂♂/ 3 of 8 x 25 cm^2.

Remarks

The prefix of the specific name *quagesetosa* is derived from abbreviations of the Latin 'quattuor' for 'four' and 'genitus' for 'be born' and refers to the four pairs of genital setae. It is the only species in the genus.

Acknowledgments

I am indebted to Miss Carolyn M. Birchby for the drawings and to Miss Kirstie Jamieson for making up the plates with their notation, as well as to the Australian Biological Resources Study for funding their salaries. Thanks are also due to Dr Robert Raven (Queensland Museum) for arranging the loan of type material and Mrs Debbie Lowery for typing the manuscript.

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CTENOPHORUS TJANTJALKA, A NEW DRAGON LIZARD (LACERTILIA: AGAMIDAE) FROM NORTHERN SOUTH AUSTRALIA

G. R. JOHNSTON

JOHNSTON, G. R. 1992. *Ctenophorus tjantjalka*, a new dragon lizard (Lacertilia: Agamidae) from northern South Australia. *Rec. S. Aust. Mus.* **26**(1): 51–59.

A new species of agamid lizard, *Ctenophorus tjantjalka*, is described and illustrated. It is saxicolous in habit, appears to be confined to northern South Australia and is a member of the *C. decresii* species group. It may be distinguished from all other members of this group by its deep head and short snout, wrinkled snout scales, the presence of a vertebral keel, dorsal colouration of males and females and the lack of banding on the tail.

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Members of the *Ctenophorus decresii* species group represent a distinct saxicolous ecomorph within the extensive Australian radiation of agamid lizards. This group has been diagnosed by Houston (1974) and extended by Storr (1981). The species described herein as new, is a member of the *C. decresii* species group and inhabits the barren, rocky ranges of far northern South Australia.

Specimens of this taxon have been received at the South Australian Museum since 1960 but were variously misidentified, most of them as either *C. rufescens* or *C. vadnappa*. Warburg's (1966) reference to *C. fionni* at Wintinna in northern South Australia was probably based on this species. White's (1979) records of *C. vadnappa* from the Mabel Range near Oodnadatta are also based on this species. Houston (1978) regarded several specimens of this new species as *C. rufescens*, thereby incorrectly extending that species' distribution east of the Stuart Highway.

Materials And Methods

Eighteen morphometric measurements and eight meristic counts were made of all available specimens of the new taxon (N = 17) and *C. rufescens* (N = 89), and a selection of *C. vadnappa* (N = 42) in the South Australian Museum (SAM) and Western Australian Museum (WAM). Morphometric measurements were snout-vent length (SVL), the distance between the tip of the snout and the anterior margin of the eye (SL), eye diameter (EYE), the horizontal distance from the posterior margin of the eye to the angle of the jaw (POCL), head depth immediately behind the eye (HD), width between the nostrils (SWD), width between the tympani (HWD), length of the upper arm (HUML), length of lower arm (FAL), length of the hand (ML), length of the thigh (FEML), length of tibia (TIBL), length of foot (PL), distance from axilla to groin (AG), tail length (TL), head length (HL = SL+EYE+POCL), forelimb length (FLL = HUML+FAL+ML) and hindlimb length (HLL = FEML+TIBL+PL). Meristic counts were the number of scales between the rostral and the nasal (PRENAS), number of scales between the nasal and the supralabials (SUBNAS), number of scales between the nasals across the top of the snout (INTERNAS), number of supralabials (SUPLAB), number of infralabials (INLAB), number of subdigital lamellae on the fourth finger (SD4F), number of subdigital lamellae on fourth toe (SD4T) and the number of femoral and preanal pores (FEMPREPO).

Descriptive statistics were calculated for a number of meristic characteristics (Table 1) from samples of *C. rufescens*, *C. vadnappa* and the new taxon. Multiple comparisons of these variables were made using single classification ANOVA (Sokal & Rohlf 1981). Multiple discriminant function analyses (Reyment *et al.* 1984) of raw measurements and meristic characteristics were done using SPSS PC+ (Norusis 1986) on a Pantek PC-16 personal computer. Sexes were pooled for all analyses.

Ontogenetic variation was examined by fitting HL, HD, HWD, FLL, FEML, ML, HLL, TL and SVL for *C. rufescens*, *C. vadnappa* and the new taxon to the logarithmic form of the allometric equation $Y = bSVL^a$ (Huxley 1932; Gould 1966), where Y is the variable being examined, SVL is used as a measure of overall size, a is the allometric coefficient (slope) and b is the y-intercept. Allometric coefficients were tested against unity using standard normal deviates (Zar 1974).

Ctenophorus tjantjalka sp. nov.
Figs 1-3, 5B

Types

Holotype: SAM R17934a just N Mabel Range, S.

Aust., 26°45′S, 113°48′E, South Australian Herpetology Group, 18-20.*iv*.1979, male.

Paratypes: SAM R4328 Mt Chandler, S. Aust. (27°00′S, 113°19′E), H. Wopfner, 20.*x*.1960; SAM R6227 80 miles W Oodnadatta, Copper Hill Station (27°57′S, 134°19′E), H. Frahn, 19.*vii*.1965; SAM R12495 20 miles S Hawks Nest Well, S. Aust. (27°45′S, 134°07′E), J. Bredl, 1971; SAM R15608 Rocky Gully, SW old Peake HS, S. Aust. (28°05′S, 135°54′E), Rostrevor College, *ix*.1976; SAM R15936a-d near Peake Ruins, S. Aust. (28°05′S, 135°54′E), T. F. Houston, 18-19.*iv*.1977 (SAM R15936a is a dried skeleton); SAM R17701 Hawks Nest Well, S. Aust. (27°30′S, 134°13′E), B. Miller and M. Galliford, 26.*iii*.1979; SAM R17934b, SAM R17935 just N Mabel Range, S. Aust. (26°45′S, 135°48′E), South Australian Herpetology Group, 18-20.*iv*.1979; SAM R20579-80 Copper Hill Station, 19km E Mt Willoughby, S. Aust. (27°57′S, 134°19′E), D. J. Morafka, 12.*iv*.1979; SAM R36731-33 Davenport Range, S. Aust. (28°27′S, 136°02′E), M. Adams and T. Reardon; SAM R37115 83km N Coober Pedy, S. Aust. (28°27′S, 134°12′E), J. Cornish, 15.*x*.1990.

Diagnosis

A member of the *Ctenophorus decresii* group (*sensu* Houston 1974 and 1978, *cf.* Storr, Smith & Johnstone 1983). Distinguishable from all other members of this group in the following combination of characters: snout scales wrinkled; vertebral keel line present, at least anteriorly; flanks with pale cream to pale salmon pink patches on a grey-brown background in adult males; large pale grey to white spots present on dorsum in females and juveniles; tail without broad alternate dark and pale bands.

Description

A robust, moderate-sized dragon lizard reaching a SVL of 73 mm and a total length of 208 mm; head relatively short and deep; snout moderately obtuse, rising fairly steeply in profile; nostril below a sharp canthus rostralis; body moderately depressed; forelimbs relatively large, reaching or almost reaching groin when adpressed; hindlimbs quite long, 94-122 percent of SVL; tail long and evenly tapering. In juveniles the head and appendages are relatively longer than in adults (Table 2).

Scales on top of snout coarsely wrinkled in adults, tending to simple keeled in juveniles; a row of enlarged, longitudinally-ridged or carinate scales from nostril below eye to above ear; outer margins of eyelids fringed with a row of acute scales; 5-7 scale rows separating

FIGURE 1. Adult male *Ctenophorus tjantjalka* (SAM R36731) from the Davenport Range, South Australia. SVL = 65mm.

FIGURE 2. Adult female *Ctenophorus tjantjalka* (SAM R37115) from 83km N Coober Pedy, South Australia. SVL = 47mm.

nasals from supralabials; 13-17 supralabial scales on each side; temporal, occipital, nuchal and axillary scales generally very small and convex; folds of skin above and behind ear opening on sides of neck with clusters of small spines, feebly developed in juveniles; low nuchal crest present; a row of perfectly aligned, keeled scales extends dorsally from the nuchal crest to the base of tail along the midline in males, may be feebly developed in females and juveniles; this keel line frequently accentuated by being raised on a fold of skin; scales on flanks small, subtubercular and homogeneous, grading into slightly larger, flatter dorsal body scales which are feebly keeled in adults to smooth in some juveniles; flanks without scattered individual tubercles; ventral scales homogeneous, smooth, substantially larger than dorsal scales and much larger than lateral scales; scales on tail and dorsal surfaces of limbs large and strongly keeled; 33-46 femoral and preanal pores regularly spaced, with 1-4 scales between pores, along a more or less straight line extending the full length of thighs, but interrupted medially; each pore surrounded by several scales, those anterior to it being slightly enlarged.

Adult males (Fig. 1) vary from dark, chocolate brown to grey dorsally, with dark grey to black reticulations which tend to form an irregular dorsolateral stripe. Paler reticulations tend to form transverse bars on flanks which interrupt dark dorsolateral stripes; these pale bars are pale cream dorsally, grading to pale salmon pink laterally. Vertebral region brown to grey, peppered with black and cream, as are the tail and limbs; tail may have irregular darker and lighter bands distally. Chest and ventral surface of forelimbs dark grey to black, tapering toward the midline caudally. Gular fold and clusters of spines on nape pale cream. Bars of grey to brown and cream radiate from the eye to the brow, and from the eye over the upper lip, and along the lower lip. Throat cream with fine, dark grey reticulations, tending to form 2-3 irregular stripes on jowls. Scapular fold black with cream edge.

Adult females (Fig. 2) brick-red to brown dorsally; cream ventrally. Irregular black transverse bars on flanks, interspersed with thinner irregular pale grey white bars. Vertebral region with irregular black and pale grey spots which may align and be continuous with lateral bars. Dorsal surfaces of limbs peppered with pale grey scales and irregular, small, black markings. Throat and chest lightly peppered with dark grey to black, becoming heavier on jowls where it tends to form 2-3 irregular stripes. Clusters of spines on nuchal region pale grey to white.

Juveniles are very similar to the females in colour and pattern; the pattern may be finer than in adults. Specimens which have been in alcohol for some time fade considerably so that the dorsum becomes pale brown and any pattern barely visible.

Measurements of Holotype (in mm)

Snout-vent length, 73.0; head length, 15.5; head width, 15.2; fore limb length, 33.3; hind limb length, 78.1; tail length, 135.

Etymology

The specific epithet is the name used by the Aboriginal people of north-western South Australia for saxicolous agamid lizards. It is used as a noun and is not subject to termination changes.

Distribution and Habitat

Widespread in the interior of South Australia, between the Indulkana Range and Oodnadatta in the north and Coober Pedy and the Davenport Range in the south (Fig. 3).

All specimens of *C. tjantjalka*, for which information is available on habitat, were collected in or among rocky outcrops. SAM R12495 was collected 'on granite outcrops'. SAM R15936a-d was collected 'in small granite outcrops in gullies' and SAM R17701 was 'active on outcrops'. White (1979) collected specimens (SAM R17934a-b, SAM R17935) ' . . . on mid to lower slopes of gibber strewn hills...' John Cornish (pers. comm. 1990) collected SAM R37115 under gibber rocks in a slight gully.

Comparison with Similar Species

Morphology

C. tjantjalka is clearly a member of the *C. decresii* species group (Houston 1974, 1978) in being of moderate size with head and body moderately to strongly depressed, showing sexual dimorphism and being of saxicoline habit. It differs from *C. ornatus* and *C. yinnietharra* in lacking extreme depression of the head and body, and having no clear broad bands of colour around the tail in males. Similarly, the head and body of *C. tjantjalka* are less depressed than those of *C. decresii*, *C. fionni*, *C. rufescens* and *C. vadnappa*. The presence of pale spots (in females) or reticulations (in males) on the dorsum distinguishes *C. tjantjalka* from *C. rufescens*, as does the lower number of femoral and preanal pores (Table 1). The snout scales of *C. tjantjalka* are consistently wrinkled, as in *C. vadnappa* (Houston 1974), which serves to distinguish it from *C. decresii* and most *C. fionni*. Male *C. tjantjalka* have pale cream to pale salmon pink areas on the flanks, as opposed to the red or orange areas

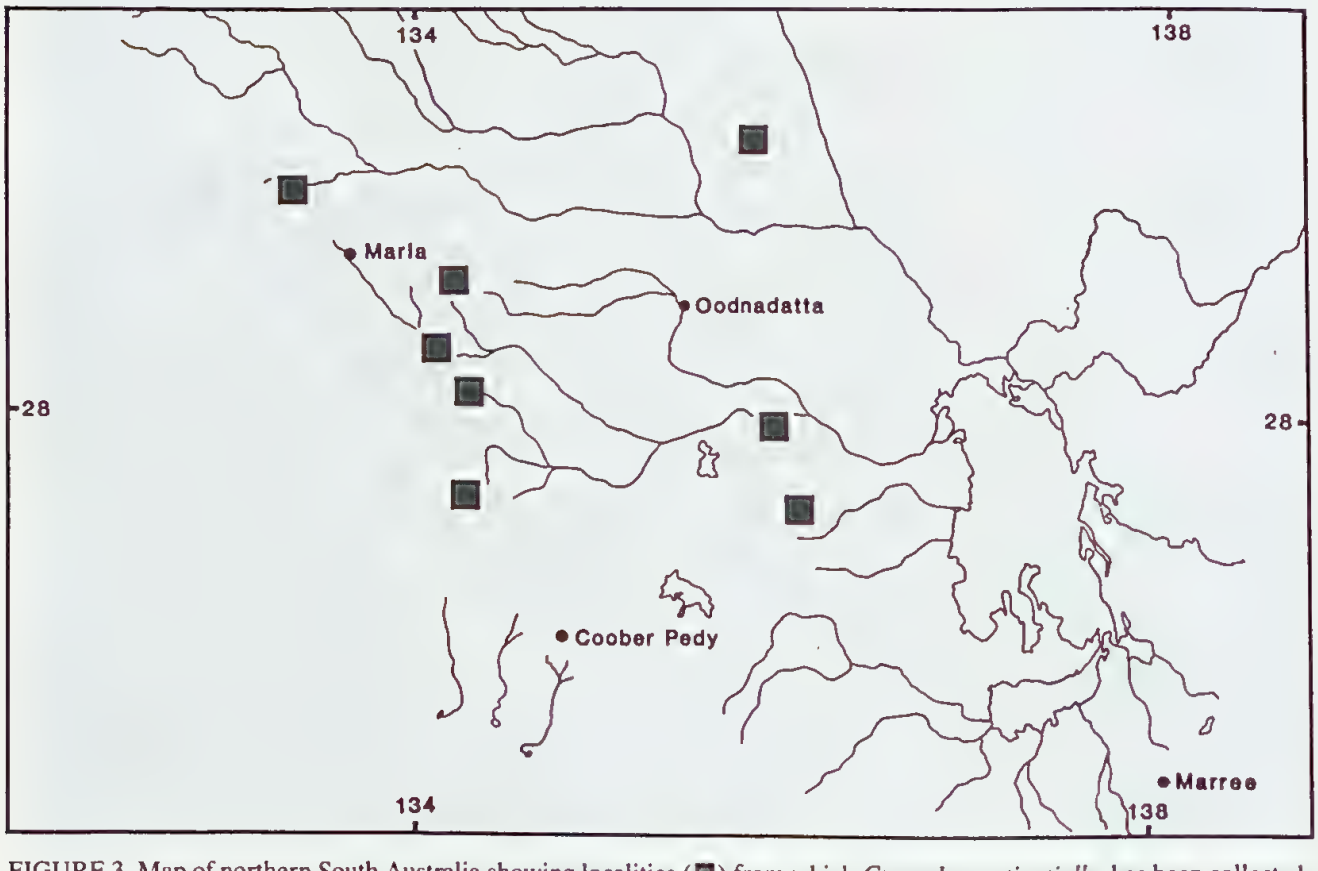

FIGURE 3. Map of northern South Australia showing localities (■) from which *Ctenophorus tjantjalka* has been collected.

on the flanks of male *C. vadnappa*. Male *C. vadnappa* are further distinguished from male *C. tjantjalka* in having a blue background dorsal colour when active. The background colour on the dorsum of *C. tjantjalka* is grey to brown. *C. tjantjalka* and *C. vadnappa* both have a vertebral line of keeled scales present, at least anteriorly, unlike *C. decresii* and *C. fionni* in which any keeled vertebral scales are associated with the nuchal crest only and do not extend behind the shoulders. *C. tjantjalka* lacks the tiny white spiny tubercles found on the flanks of *C. decresii*. Female *C. tjantjalka* may be distinguished from all other members of the *C. decresii* group in having large pale grey spots on the dorsum. The relatively deep head and short snout distinguish both sexes of *C. tjantjalka* from all other members of the *C. decresii* group.

Although all meristic characters counted showed statistically significant differences ($P < 0.01$) between *C. tjantjalka*, *C. rufescens* and *C. vadnappa*, the actual counts for all except FEMPREPO overlapped extensively (Table 1).

Several populations of *C. caudicinctus* are similar in general morphology to members of the *C. decresii* group. This may be due to their being of similar saxicolous habit. Houston (1974) has suggested that the *C. decresii* group may share a common ancestry with some populations currently subsumed under the epithet *C. caudicinctus*. The deeper head and less depressed body of *C. tjantjalka*, relative to other members of the *C. decresii* group, are reminiscent of some populations of *C. caudicinctus*. These taxa may be distinguished by the presence of clusters of small spines on folds of skin on the nape and neck of *C. tjantjalka* which are absent or poorly developed in *C. caudicinctus*. The forelimbs of all members of the *C. decresii* group show negative allometric growth (Table 2; Witten 1985) whereas in *C. caudicinctus* the forelimbs grow isometrically (Witten 1985).

Distribution

C. tjantjalka is allopatric to all other members of the *C. decresii* group and *C. caudicinctus*. The only species which are likely to be confused with *C. tjantjalka* on grounds of distribution are *C. rufescens* and *C. vadnappa*. Both of these species occur on rocky ranges abutting the known distribution of *C. tjantjalka*.

Discriminant Function Analysis

Discriminant function analysis of 15 measurements, using *C. rufescens*, *C. tjantjalka* and *C. vadnappa* as *a priori* groupings (Fig. 4), resulted in correct identification of 92.5% of specimens overall. All *C. tjantjalka*, 93.1% of *C. rufescens* and 89.8% of *C. vadnappa* were correctly grouped. FLL, HLL and HL were not included in the analysis because they failed to contribute significantly to a decrease in Wilk's lambda. A separate discriminant function analysis of eight meristic characteristics, also using *C. rufescens*, *C. tjantjalka* and *C. vadnappa* as *a priori* groupings, resulted in correct identification of 89.0% of specimens overall. All *C. rufescens*, 82.1% of *C. vadnappa* and 83.3% of *C. tjanjalka* were correctly grouped.

The first discriminant function based on measurements accounted for 78.1% of the variance. Unstandardised discriminant function coefficients and their correlations to the discriminant functions are presented in Table 3. Most characters showing the highest correlation with the first discriminant function,

TABLE 1. Comparison of meristic characters for three species of *Ctenophorus*. Values represent mean (standard deviation) over minimum-maximum.

	C. rufescens	*C. tjantjalka*	*C. vadnappa*
N	55	17	42
FEMPREPO	54.9(2.33) 43-67	38.8(1.96) 33-46	39.7(1.98) 33-47
PRENAS	5.8(0.84) 5-7	4.9(0.85) 3-6	5.1(0.81) 3-6
SUBNAS	6.5(0.85) 5-9	6.2(0.86) 5-7	5.7(0.83) 5-6
INTRANAS	13.1(1.12) 11-17	10.2(1.22) 8-15	10.3(0.97) 8-13
SUPLAB	17.4(1.20) 13-20	18.4(1.06) 13-17	15.0(0.96) 13-16
INLAB	15.6(1.16) 12-19	16.4(1.09) 13-18	15.4(0.90) 14-17
SD4F	19.2(1.15) 16-22	16.6(1.23) 14-19	17.0(1.04) 15-19
SD4T	31.8(1.42) 26-36	28.7(1.63) 24-34	27.6(1.41) 23-33

TABLE 2. Relative growth of body parts in three species of *Ctenophorus*. Regression lines of the form $y = bx^a$ were fitted to the data. R^2 = coefficient of determination; N = sample size; C_{30} = predicted size of body part at a SVL of 30mm; C_{80} = predicted size of body part at a SVL of 80mm. Allometric coefficients were compared to isometry using standard normal deviates: * = $P<0.05$, ** = $P<0.01$.

	R^2	*a*	*b*	N	C_{30}	C_{80}
			Ctenophorus rufescens			
HLvSVL	0.87	0.8150**	−0.8571	55	6.8	15.1
TLvSVL	0.76	0.9616	0.9794	49	70.1	180.0
FLLvSVL	0.79	0.8254**	−0.0261	55	16.1	36.2
HLLvSVL	0.91	0.8527**	0.6379	55	34.4	79.4
FEMLvSVL	0.82	0.9006	−0.8689	55	9.0	21.7
PLvSVL	0.86	0.7793**	0.0407	55	14.7	31.7
HWDvHL	0.89	0.8997*	0.2417	55	7.1	14.6
HDvHL	0.42	0.7984	0.0140	55	4.7	8.9
SLvHL	0.93	0.9858	−0.6017	55	3.6	8.0
			Ctenophorus tjantjalka			
HLvSVL	0.97	0.9013*	−1.0828	19	7.3	17.6
TLvSVL	0.78	0.8951	1.1501	15	66.3	159.6
FLLvSVL	0.94	0.8379**	−0.0789	19	16.0	36.3
HLLvSVL	0.91	0.8264**	0.7705	19	35.9	80.7
FEMLvSVL	0.91	0.9615	−1.1160	19	8.6	22.1
PLvSVL	0.70	0.6874**	0.4450	19	16.1	31.7
HWDvHL	0.95	0.8813*	0.2544	19	7.4	14.5
HDvHL	0.88	1.0687	−0.5733	19	4.7	10.6
SLvHL	0.94	1.0794	−0.8771	19	3.5	8.1
			Ctenophorus vadnappa			
HLvSVL	0.92	1.0213	−1.5968	40	6.5	17.8
TLvSVL	0.95	1.0676	0.4676	30	60.3	171.7
FLLvSVL	0.92	0.8535**	−0.1758	41	15.3	35.3
HLLvSVL	0.90	0.9424	0.1933	41	29.9	75.4
FEMLvSVL	0.98	1.0563	−1.5685	41	7.6	21.3
PLvSVL	0.76	0.8194*	−0.2254	41	13.0	28.9
HWDvHL	0.61	0.9413	0.0585	40	6.2	15.9
HDvHL	0.94	0.9671	−0.4281	40	4.0	10.6
SLvHL	0.94	0.9412	−0.5052	40	3.5	9.1

which most clearly separates *C. rufescens* from *C. tantjalka* and *C. vadnappa*, are measurements of the limbs. Most characters showing the highest correlation with the second discriminant function, which most clearly separates *C. tjantjalka* from *C. rufescens* and *C. vadnappa*, are measurements of the head. This reflects the differences in the relative proportions of the limbs and heads of the three species (Fig. 5).

Allometry

Relative growth among ten body parts in *C. rufescens*, *C. tjantjalka* and *C. vadnappa* is summarised in Table 2. *C. rufescens* and *C. tjantjalka* share the same pattern of relative growth. The head and limbs show negative allometry with respect to SVL. While the head decreases in size relative to SVL, the head width also decreases in size relative to the head length. Much of the relative shortening of the hindlimb with increasing size is accounted for by negative allometry of the foot.

In *C. vadnappa* only the forelimbs shorten with increasing SVL, while all other body parts grow isometrically. Although overall the hindlimb length grows isometrically with respect to SVL, the proportions of the hindlimb change so that the foot becomes relatively shorter with respect to the rest of the limb.

Witten (1985) has studied relative growth in the majority of species of Australian agamids, but did not have data for *C. rufescens* or *C. vadnappa*. In both of these species and *C. tjantjalka* the tail grows isometrically, whereas Witten (1985) implies that in other species of the *C. decresii* group the tail shows positive allometry. In fact Witten (1982 and pers. comm. 1991) found significant positive allometry in the tail of *C. fionni*, but in other members of the

TABLE 3. Unstandardised discriminant function coefficients (and pooled-within-groups correlations with discriminant functions) of 15 measurements of three species of saxicolous *Ctenophorus*.

	Discriminant Function	
Variable	I	II
SVL	−0.046(−0.277)	0.193(0.378)
SL	1.232(−0.083)	0.426(0.316)
EYE	0.530(−0.170)	−1.501(0.179)
POCL	1.191(0.175)	0.316(0.327)
SWD	0.032(−0.174)	0.511(0.337)
HWD	−0.101(−0.140)	−0.113(0.194)
HD	0.302(0.003)	−0.271(0.053)
HUML	−0.701(−0.377)	−0.073(0.223)
FAL	0.042(−0.226)	−0.051(0.257)
ML	0.239(−0.229)	0.226(0.344)
FEML	−0.243(−0.305)	−0.130(0.260)
TIBL	−0.039(−0.281)	−0.154(0.185)
PL	−0.060(−0.349)	−0.366(0.097)
AG	−0.009(−0.332)	−0.034(0.358)
TL	−0.023(−0.368)	0.035(0.394)
constant	1.835	0.687
% of variance	78.06	21.94

C. decresii group he studied, the allometric coefficient for tail length was above one but not significantly so. In *C. rufescens* and *C. tjantjalka* the hindlimb shows negative allometry, in concordance with most other Australian agamids, whereas in *C. vadnappa* the hindlimb grows isometrically. Similarly head length in *C. rufescens* and *C. tjantjalka* shows negative allometry, in common with other Australian agamids, whereas the head of *C. vadnappa* grows isometrically. In most species of Australian agamids the forelimb shows negative allometry. The negative allometry or isometry of head width and head depth relative to head length in all three species is unusual among Australian agamids, in which these measurements generally show positive allometry.

Discussion

Ctenophorus tjantjalka is described as a new species primarily on the basis of the remarkable consistency of its morphology across a large geographic range. In general, members of the *C. decresii* complex are characterised by a large amount of population structuring (Gibbons & Lillywhite 1981) and consequent morphological (Houston 1974) and genetic variation (Johnston & Donnellan, unpublished data) among populations within species.

One feature of *C. tjantjalka* is its robust appearance when compared with other members of the *C. decresii* species group, which are moderately to extremely dorsoventrally compressed. In this respect adult *C. tjantjalka* resemble juveniles of other members of the *C. decresii* group. Cogger (1961) has demonstrated that heterochronic processes are an important source of morphological variation among Australian dragon lizards. In the absence of any knowledge of the phylogenetic relationships among the various species groups within the genus *Ctenophorus* it is not possible to determine whether *C. tjantjalka* has arisen through some form of paedomorphosis, or whether it represents a more 'plesiomorphic' form and all other members of the *C. decresii* group have undergone a type of peramorphosis (Alberch *et al.* 1979). This dilemma emphasises the need for a formal phylogenetic analysis of the Australian agamid lizards.

The geographic distribution of *C. tjantjalka* lies directly between those of *C. rufescens* and *C. vadnappa*. It therefore provides evidence to support Houston's (1974) hypothesis that the ancestors of *C. decresii*, *C. fionni* and *C. vadnappa* were once distributed along the western side of Lake Eyre and may have been derived via that route from a common ancestor with *C. rufescens*, among other saxicolous dragon lizards. Gibbons & Lillywhite (1981) have suggested that the *C. decresii* species group may have been derived from a hypothetical ancestor in western Queensland via the corridor of rocky country provided by the Grey Range, Barrier Range and Olary Spur, but there seems to be little to support this alternative hypothesis.

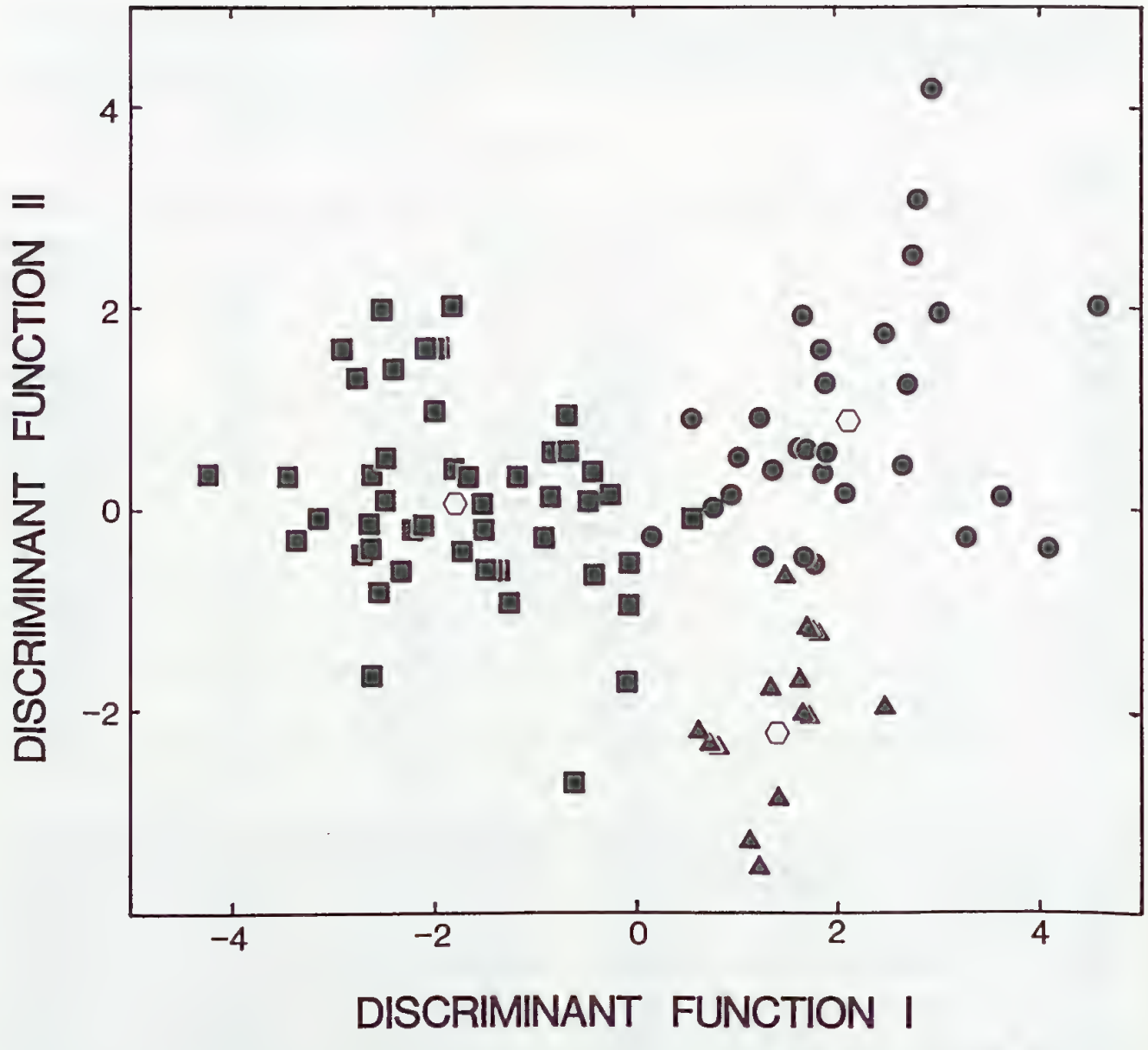

FIGURE 4. Plot of individual *Ctenophorus tjantjalka* (▲), *Ctenophorus rufescens* (■) and *C. vadnappa* (●) on the first two discriminant function axes based on fifteen morphometric characters. (○) = group centroids.

Comparative Material Examined

C. rufescens

WAM R28990-91 Pottoyu Hills (25°19′S, 129°49′E), 10.*v*.1967; SAM R586a-b Everard Range (27°06′S, 132°26′E), no date; SAM R586c Wantapella Swamp (27°02′S, 133°28′E), no date; SAM R1423-25 Mt Sir Thomas, Birksgate Range (27°09′S, 129°44′E), no date; SAM R3125a-c Ernabella Mission (26°18′S, 132°08′E), 10.*x*.1950; SAM R5632 Mann Range (26°01′S, 129°45′E), *vi*.1964; SAM R11754-56 Everard Range (27°06′S, 132° 26′S), 1-7.*xi*.1970; SAM R13219 1.5 miles S Mt Illbillee, Everard Range (27°04′S, 132°29′E), 24.*x*.1972; SAM R13220 nr Mt Davies Bore, Tomkinson Range (26°10′S, 129°08′E), 18.*x*.1972; SAM R13221a-f 3 miles SW Mt Edwin, Mann Range (26°07′E, 129°56′E), 22.*x*.1972; SAM R28274-80, SAM R28289 nr Victory Well, Everard Range (27°03′S, 132°31′E), 25-26.*viii*.1987; SAM R28283-84 between Victory Well and Betty Well, Everard Range (27°03′S, 132°31′E), 26.*viii*.1987; SAM R31772 2.4 km E Mimili (27°01′S, 132°44′E), 10.*xii*.1987; SAM R31773-4 19.2 km W Mimili (26°57′S, 132°32′E), 10.*xii*.1987; SAM R31791, SAM R35828 45.5 km SE Fregon (26°54′S, 132°24′E), 19.*xii*.1987; SAM R33940-2, SAM R33947-48, SAM R35829 Mimili (27°01′S, 132°43′E), 11.*iv*.1989; WAM R31768-80 Mt Lindsay, Birksgate Range (27°02′S, 129°53′E), *viii*.1968; WAM R44341-69 Mt Lindsay, Birksgate Range (27°02′S, 129°53′E), 1.*ix*.1972; WAM R44370-71 Mt Wooltarlinna, Birksgate Range (27°04′S, 129°51′E), 1.*ix*.1972; WAM R44385-87 Mt Kintore (26°34′S, 130°29′E), *ix*.1972; WAM R44341 Blackstone Mining Camp, Blackstone Range (26°01′S, 128°22′S), 29.*viii*.1972.

C. vadnappa

SAM R457 Farina (30°04′S, 138°17′E), 8.*iv*.1915; SAM R3764a-d Marree Picnic Ground (29°39′S, 138°04′E), 1.*xi*.1955; SAM R10959 East Painter Gorge (30°14′S, 139°22′E); 31.*x*.1969; SAM R12505 Yudnamutana (30°10′S, 139°17′E), 10.*ix*.1970; SAM R13547 Terrapinna Spring

(29°58′S, 139°40′E), 17.*vi*.1960; SAM R13943a-b Finniss Creek W Marree (29°38′S, 137°31′E), 10-15.*i*.1974; SAM R14481 Aroona Reservoir (30°35′S, 138°22′E), 15.*i*.1974; SAM R15098a-b Aroona Dam (30°35′S, 138°22′E), no date; SAM R15956a-d Mt Serle (30°32′S, 138°53′E), 10.*iv*.1977; SAM R16159 Mt Serle (30°31′S, 138°55′E), 4.*ix*.1977; SAM R16189a-b Termination Hill, 26km W Lyndhurst (30°15′S, 138°03′E), 8.*x*.1977; SAM R19284 10 miles W Arkaroola village (30°47′S, 138°30′E), 16.*ii*.1981; SAM R19884-5 15km W Copley (30°30′S, 138°25′E), 25.*iv*.1981; SAM R24430-31 W end Brachina Gorge, Flinders Ranges (31°21′S, 138°33′E), 20.*viii*.1983; SAM R24906-7 Grindells Hut, Gammon Ranges (30°28′S, 139°12′E), 25.*xi*-1.*xii*.1983; SAM R28098 5km N Copley (30°30′S, 138°25′E), 16.*viii*.1985; SAM R28625-6 Arkaroola (30°20′S, 139°22′E); SAM R29575 Marree Picnic Ground (29°39′S, 138°04′E), 23.*viii*.1985; SAM R30051-3 30.6km S Lyndhurst (30°32′S, 138°25′E), 21.*ix*.1985; SAM R30054 3.5km S Arkaroola (30°22′S, 139°27′E), 31.*ix*.1985; SAM R30999 32km S Lyndhurst (30°32′S, 138°25′E), 8.*xi*.1986; SAM R31002 Aroona Dam (30°35′S, 138°22′E), 23.*viii*.1986; SAM R31216 5.4km NW Copley (30°32′S, 138°25′E), 8.*xi*.1986; SAM R31219-22 Italowie Gap, Gammon Ranges (30°33′S, 139°10′E), 4-8.*iv*.1985.

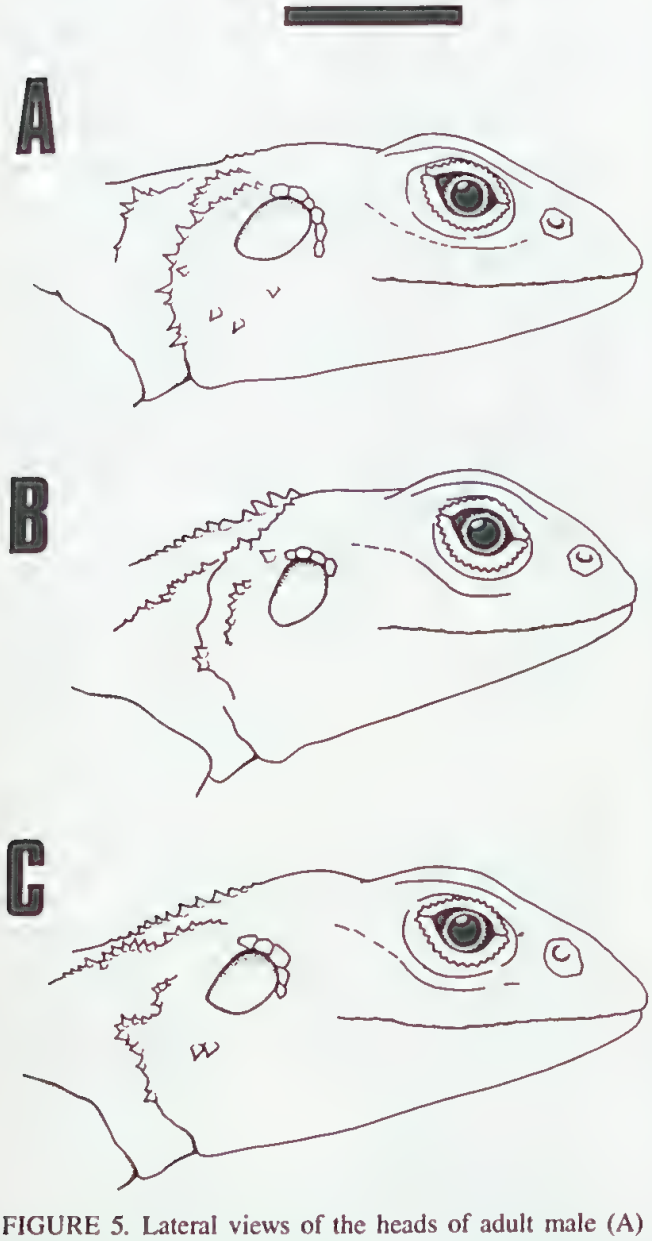

FIGURE 5. Lateral views of the heads of adult male (A) *Ctenophorus rufescens* (SAM R13221c), (B) *Ctenophorus tjantjalka* (SAM R17934a) and (C) *C. vadnappa* (SAM R16189a). Scale bar = 10mm.

Acknowledgments

A. Edwards and M. Hutchinson (SAM) and L. Smith (WAM) allowed access to specimens held in their care. S. Donnellan and J. Cornish provided Figures 1 and 2, respectively. Field work for this paper was funded in part by the Peter Rankin Trust Fund for Herpetology. C. M. Bull, M. Hutchinson and G. Witten made helpful comments on the manuscript.

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THE CROCKERS WELL METEORITE: AN UNUSUAL LL7 BRECCIA FROM SOUTH AUSTRALIA

MARGARET E. WALLACE

WALLACE, M. E. 1992. The Crockers Well meteorite: An unusual LL7 breccia from South Australia. *Rec. S. Aust. Mus.* 26(1): 61–65.

The Crockers Well, South Australia, meteorite is a rare type LL7 chondrite. The 3.8 gram stone was found in 1956 by J. E. Johnson. Crockers Well has a brecciated texture and a mineral chemistry which indicates that it is an LL-type chondrite. It has equilibrated at unusually high temperatures (950 to 1 100°C) and appears to be a shock breccia which has recrystallized at depth. Crockers Well is the first LL7-type meteorite to be found in Australia and is similar to the Antarctic meteorites Yamato 74160 and Yamato 791067.

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Manuscript received 29 November 1991.

The Crockers Well meteorite weighing 3.8 grams was found in 1956 by James Eric Johnson, of the South Australian Department of Mines and Energy. Mr Johnson was surveying for uranium when he found the small meteorite on a granite hill 0.4 kilometres north of the East Crocker uranium prospect, near Crocker Well camp, north–west of Plumbago Homestead, County Lytton, South Australia (32°01′S, 139°47′E, see Fig. 1). Only one specimen was found.

The meteorite was presented to the South Australian Museum by Mr Johnson in 1956 and the discovery recorded by Corbett (1968). The name Crockers Well used in this report is synonymous with Crocker Well and Crocker's Well (Clarke 1976; Fitzgerald 1979; Graham *et al.* 1985) and has been approved by the nomenclature committee of the Meteoritical Society.

The meteorite is a small button-shaped stone (18 × 15 × 12 mm) with a fusion crust coating one side. It is moderately iron-stained. Due to its small size, the stone remained uncut in the museum's collection for 34 years and thus was only described as an unclassified chondrite. Fitzgerald (1979) suggested that it may be related to Ethiudna, a large 74.32 kilogram chondrite found 6.5 kilometres away.

In 1990 a thin-section was made in order to gain textural and mineralogic information and to classify the meteorite properly. In making the thin-section, special care was taken not to damage the fusion crust as this is important for establishing the meteorite's extraterrestrial origin. The remaining 2.38 gram piece resides in the meteorite collection of the South Australian Museum (catalogue number G5909). A brief description and classification of the meteorite was presented by Wallace & Pring (1991). The stone is not related to Ethiudna but is a rare type LL7 chondrite of which only three examples have been found to date. This paper presents a detailed petrographic and mineralogic description of the Crockers Well meteorite in order to provide constraints on the origin and physical history of this rare type of chondritic meteorite.

Texture

In thin-section, Crockers Well has a brecciated texture with no visible chondrules. It is composed of large clasts and rounded olivine grains set in a finer grained matrix of broken olivine, pyroxene and feldspar fragments (Fig. 2). The clasts are sub-angular, up to 7 mm across, coarsely crystalline and composed of olivine, orthopyroxene, clinopyroxene, plagioclase and chromite with minor amounts of chlorapatite and metal. Within the clasts, the silicate minerals generally have a granoblastic texture with good triple point boundaries, typical of recrystallization. Some remnant but now recrystallized poikilitic textures are also preserved. Mineral grains are coarse for a chondrite, up to 200μm in size. In addition to clasts there are some large fragments of olivine, up to 3 mm in size, which have rounded boundaries and show some fracturing. Olivine grains have straight extinction, so appear to be relatively unstrained. They contain many small inclusions of orthopyroxene, plagioclase and troilite. The matrix is an assemblage of poorly sorted broken fragments of silicate minerals. Finer matrix material appears to be recrystallized and no glass was detected. Iron-nickel metal and troilite are present only in the clasts and do not occur as part of the matrix assemblage. A thin glassy fusion crust is present along one side of the thin-section.

Mineral Chemistry

Crockers Well is an olivine, two pyroxene, plagioclase and chromite assemblage with minor amounts of chlorapatite, iron-nickel and troilite. Compositions of the silicate phases were analyzed with a JEOL electron microprobe using an EDS system at the University of Adelaide. Analyses were made using an accelerating voltage of 15 kV, a sample current of 5 nA, and a beam width of 5μm. In order to analyse equilibrium assemblages sample points were selected

in seven distinct clasts within the thin-section. These areas are indicated in Fig. 2. Three matrix areas were also analysed to determine if matrix mineralogy was different from clast mineralogy and random analyses were performed throughout the section in order to detect any heterogeneity. Representative crystal analyses are presented in Table 1. All silicate analyses obtained have been plotted in Fig. 3.

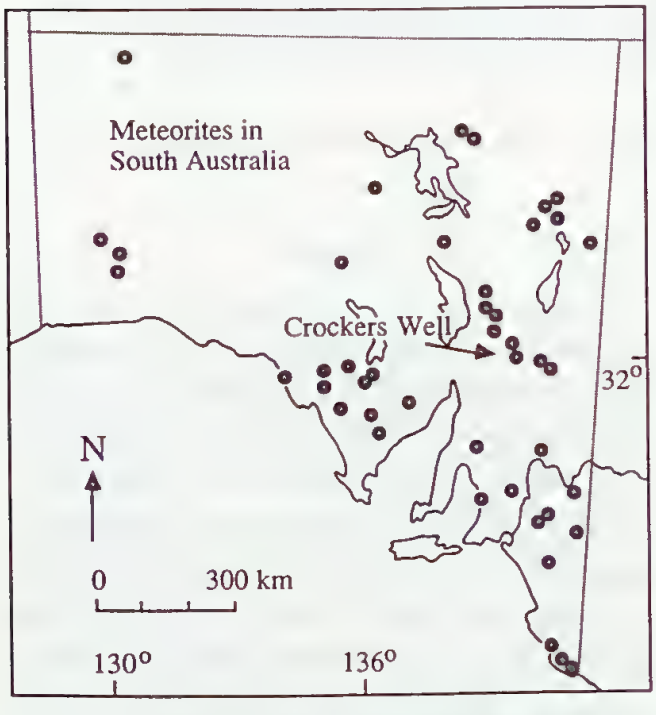

FIGURE 1. Map of South Australia showing location of Crockers Well and sites of other meteorite finds in the state.

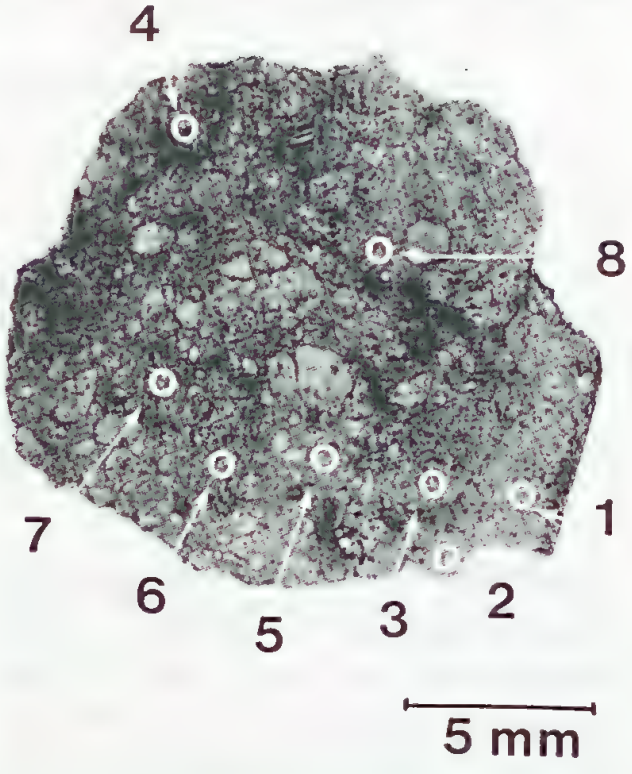

FIGURE 2. Thin-section microphotograph of Crockers Well. Numbers show areas of detailed microprobe analyses.

Olivine

Olivine is equilibrated showing a narrow range in composition with a mean fayalite content of $Fa_{30.0 \pm 0.5}$ (32 analyses). Calcium content was below the detection limit of the microprobe. There was no chemical difference detected between matrix, clast or large olivine crystals.

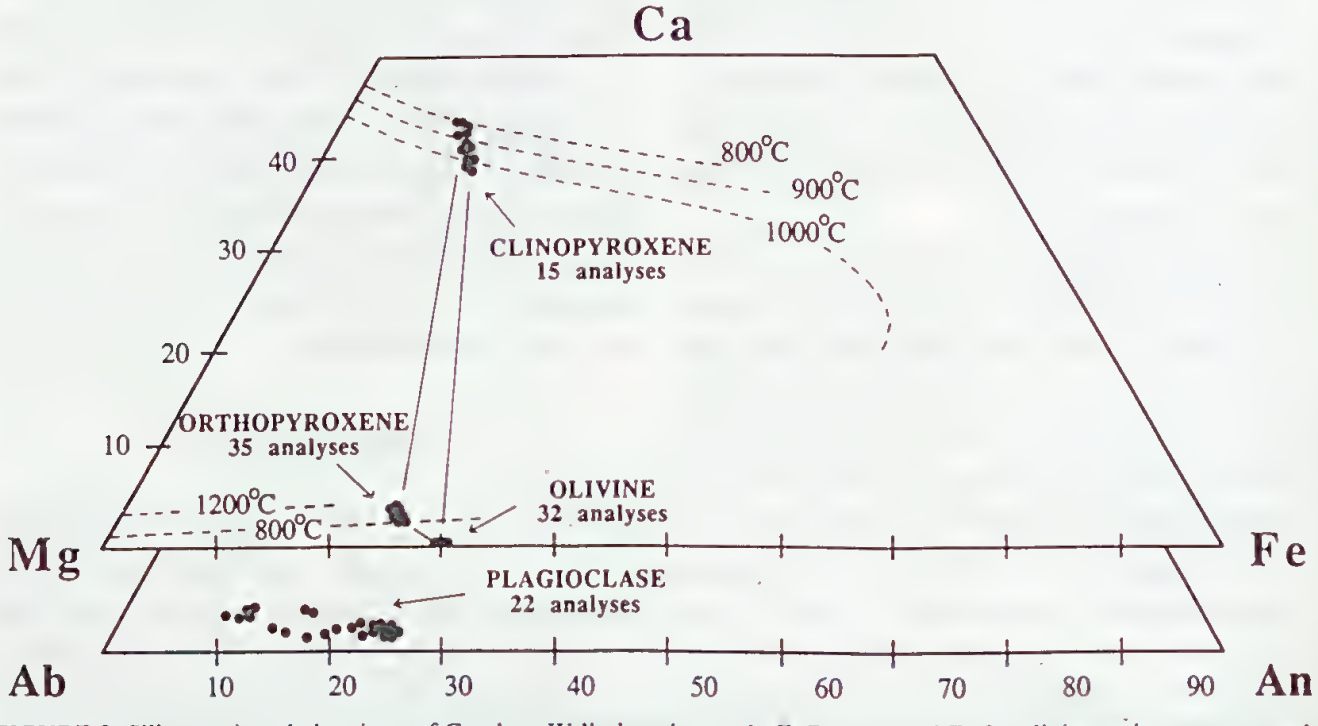

FIGURE 3. Silicate mineral chemistry of Crockers Well plotted as mol. % Ca, Mg, and Fe for olivine and pyroxenes, and Ab (albite), An (anorthite) and Or (orthoclase) endmembers for feldspars. Isotherms show temperature calculations based on the calcium content of orthopyroxene and clinopyroxene from Lindsley (1983).

Orthopyroxene

Orthopyroxene has a very narrow range of compositions with no detectable zoning within grains nor a chemical variation between grains within the matrix or clasts. Orthopyroxene iron content represented by the ferrosilite component is $Fs_{23.9 \pm 0.8}$ (34 analyses). This is particularly iron rich, but within the range of LL group chondrites as shown in Fig. 4 (Keil & Fredriksson, 1964). The high iron content of both the olivine and orthopyroxene suggests that the meteorite is highly oxidized. The orthopyroxenes have a distinctly high calcium content with the wollastonite component varying from $Wo_{2.5}$ to $Wo_{4.0}$ (mean of $Wo_{3.2}$). This is very calcium rich for ordinary chondrites but within the range of the high temperature type 7 grouping (>1.0% CaO, Dodd 1981).

Clinopyroxene

Clinopyroxene compositions range in ferrosilite content from $Fs_{9.9}$ to $Fs_{12.8}$, and wollastonite content of $Wo_{39.2}$ to $Wo_{43.6}$ (16 analyses). They are augites which are particularly high in sodium (0.6 to 1.01 wt% Na_2O) and chromium (1.04 to 1.57 wt% Cr_2O_3). Typically LL6 chondrites contain 0.5 wt% Na_2O and 0.6 wt% Cr_2O_3. The clinopyroxenes in Crockers Well are similar to those found in the Yamato 74160 (LL7) meteorite. Yamato 74160 contains augites with 0.53-0.66 wt% Na and 0.86-1.52 wt% Cr (Takeda *et al.* 1984). Takeda *et al.* (1984) suggest that this results from a high ureyite ($NaCrSi_2O_6$) component indicating either a high temperature or coexistence with a melt. Geothermomic calculations using the two pyroxene geothermometer of Wells (1977) based on the distribution of calcium in coexisting ortho- and clinopyroxenes show that Crockers Well reached temperatures between 950 and 1 100°C.

Plagioclase

Plagioclase crystals are very large up to 150 μm and show the widest range in composition, $Ab_{74.4\text{-}91.3}$ $An_{6.5\text{-}24.1}$ $Or_{1.2\text{-}4.3}$ (30 analyses). The chemical distribution is shown in Fig. 3. A thin lamellar structure can be seen in thin-section but was not chemically distinct enough to find by microprobe imaging.

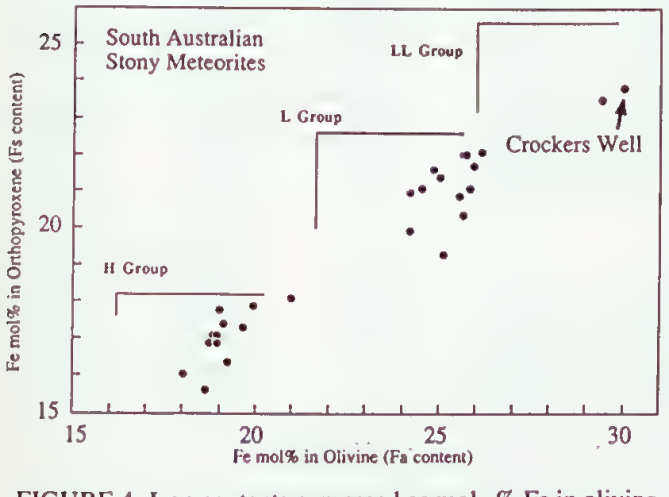

FIGURE 4. Iron contents expressed as mol. % Fe in olivine (Fa) and orthopyroxene (Fs) of South Australian stony meteorites. Classification groups are from Keil & Fredriksson (1964).

Opaque minerals

Opaque minerals are chromite, troilite and iron-nickel metal. They occur as equigranular grains within clasts. Chromite in Crockers Well is richer in Cr and Fe and poorer in Al than normally found in chondrites (as described by Bunch *et al.* 1967). High iron may be due to a higher than normal oxygen fugacity while high chromium reflects abnormally high temperatures. The sulphide is troilite with no detectable nickel. Iron-nickel metal is predominantly taenite. No martensite was found.

Discussion

Although Crockers Well has a brecciated rather than chondritic texture, mineral chemistry indicates that the meteorite was formed from LL-type chondritic material. The compositions of the minerals are similar to those found in ordinary chondrites, except that element partitioning (particularly Ca, Na and Cr) between silicate phases indicates that the meteorite equilibrated at unusually high temperatures (950 to 1 100°C) and under relatively oxidizing conditions. The silicate minerals in the type LL7 chondrites Yamato 74160, Yamato 791067 and Uden have a similar compositional range (Takeda *et al.* 1979, 1984; Yanai & Kojima 1987; Heyse 1978). The presence of metal in clasts, but rarely within matrix material, suggests that the meteorite may have partially melted near the FeS-Fe eutectic at 1 000°C.

Brecciated textures in LL-type meteorites are normally attributed to shock processes. Strongly shocked meteorites are characterised by severe melting, vesiculation, presence of a brown glassy matrix, maskelynite instead of plagioclase and martensite rather than kamacite and taenite (Stoffler *et al.* 1988; Okano *et al.* 1990). These shock features are not present in Crockers Well. Evidence of shock is restricted to extreme brecciation and possibly to the mobility of metals. Crockers Well may, however, be a shock breccia which has recrystallized and equilibrated at depth. Slow cooling after brecciation would result in recrystallization of glass and fine matrix material while preserving a record of high temperature in the silicate compositions. A thermal history study of Crockers Well involving compositions of the coexisting metals kamacite and taenite (Wood 1967) may provide further constraints.

In summary, Crockers Well is an LL7-type meteorite. Its brecciated texture and high temperature mineral chemistry record a period of intense shock. Slow cooling at depth in its parent body has resulted in the

TABLE 1. Representative electron microprobe analyses (EDS), Crockers Well meteorite.

	Clast #1	#1b	#4	#5	#8	Matrix	Matrix b
Olivine							
SiO_2 wt%	37.47	–	37.40	37.50	37.77	37.40	37.78
FeO	27.46	–	27.01	28.06	27.55	27.72	26.70
MnO	0.31	–	0.26	0.38	0.40	0.28	0.30
MgO	36.31	–	36.04	36.22	36.44	35.71	35.73
Total	101.55	–	100.71	102.16	102.16	101.11	100.51
Mg#	70.2	–	70.4	69.7	70.2	69.7	70.5
Orthopyroxene							
SiO_2	54.62	54.95	55.40	55.41	55.77	55.53	55.32
Al_2O_3	0.13	0.24	0.19	0.10	0.10	0.47	0.34
Cr_2O_3	0.16	0.34	0.15	0.28	0.37	0.53	0.19
FeO	15.71	15.37	15.99	16.12	15.89	15.94	16.72
MnO	0.39	0.19	0.35	0.25	0.44	0.34	0.32
MgO	26.79	26.99	27.08	27.49	27.12	26.89	27.69
CaO	1.58	1.84	1.34	1.64	1.74	2.06	1.34
Total	99.38	99.92	100.50	101.29	101.43	101.76	101.92
Mg#	72.9	73.1	73.2	72.9	72.7	72.1	72.8
Fe#	24.0	23.3	24.2	24.0	23.9	24.0	24.7
Ca#	3.1	3.6	2.6	3.1	3.4	4.0	2.5
Clinopyroxene							
SiO_2	54.37	–	54.48	53.98	53.62	54.80	53.74
TiO_2	0.30	–	0.28	0.27	0.30	0.32	0.26
Al_2O_3	0.65	–	0.54	0.85	0.48	0.93	0.60
Cr_2O_3	1.38	–	1.37	1.57	1.27	1.47	1.09
FeO	7.11	–	6.86	7.65	7.67	7.98	7.32
MgO	16.46	–	16.23	16.29	16.31	16.89	16.32
CaO	19.81	–	20.44	19.15	18.89	19.19	19.51
Na_2O	0.90	–	0.85	0.81	0.75	0.82	0.77
Total	100.98	–	101.05	100.57	99.29	102.40	99.61
Mg#	47.4	–	46.7	47.4	47.7	48.0	47.4
Fe#	11.5	–	11.1	12.5	12.6	12.7	11.9
Ca#	41.1	–	42.3	40.1	39.7	39.2	40.7
Plagioclase							
SiO_2	64.18	65.50	64.37	67.24	66.73	64.97	64.15
Al_2O_3	23.43	22.11	23.17	20.98	21.62	22.31	21.61
FeO	0.81	0.38	0.27	0.76	0.36	0.80	0.94
CaO	4.84	3.41	4.51	2.08	2.69	3.95	3.37
K_2O	0.33	0.50	0.36	0.74	0.65	0.28	0.63
Na_2O	8.80	9.57	9.02	9.53	9.27	9.50	9.18
Total	102.39	101.47	101.70	101.33	101.32	101.81	99.88
Ab	75.3	80.4	76.8	85.4	82.9	80.1	80.1
An	22.9	15.8	21.2	10.3	13.3	18.4	16.2
Or	1.9	3.8	2.0	4.3	3.8	1.5	3.6
Chromite						**Apatite**	
TiO_2	1.99	–	2.34	3.27	1.97	P_2O_5	41.55
Al_2O_3	4.14	–	5.46	4.50	5.46	FeO	0.22
Cr_2O_3	57.58	–	59.43	59.24	60.21	CaO	53.67
FeO	32.95	–	32.32	33.12	31.83	Na_2O	0.32
MnO	0.44	–	0.48	0.34		Cl	8.54
MgO	1.54	–	1.60	1.60	1.90		
Total	98.64	–	101.63	102.07	101.37		104.30

Mg#=Mg/(Mg+Fe) cations, Fe#=Fe/(Fe+Mg+Ca) cations, Ca#=Ca/(Fe+Mg+Ca) cations
Ab=albite, An=anorthite, Or=orthoclase end member compositions

recrystallization of fine grained matrix material, equilibrium of mineral phases and the preservation of high temperature mineral chemistry.

The meteorite record has provided many examples of brecciated LL-type chondrites most of which are interpreted as surface regolith material from the LL-parent body. These chondrites show various degrees of shock melting, recrystallization and brecciation due to intense impacts. Crockers Well appears to be one of the more unusual meteorites which preserves a record of shock-melting but also shows subsequent recrystallization at depth.

Acknowledgments

Gerr Horr is thanked for making thin-sections. The University of Adelaide is acknowledged for providing access to their electron microprobe facilities. The project was funded by the Mark Mitchell Foundation.

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A NEW GENUS OF THE BRYOZOAN SUPERFAMILY SCHIZOPORELLOIDEA, WITH REMARKS ON THE VALIDITY OF THE FAMILY LACERNIDAE JULLIEN, 1888

S. A. PARKER & D. P. GORDON

PARKER, S. A. & GORDON, D. P. 1992. A new genus of the bryozoan superfamily Schizoporelloidea, with remarks on the validity of the family Lacernidae Jullien, 1888. *Rec. S Aust. Mus.* 26(1): 67–71.

Vitrius gen. nov. is proposed for the cheilostome bryozoan *Schizoporella insignis* Hincks (Recent, Africa, Australia and New Zealand). It appears to be related to *Lacerna* Jullien, *Phonicosia* Jullien, and *Cribellopora* Gautier, sharing with them a calcareous cryptocystidean shield with conspicuous areolae, bordered by a narrow gymnocyst, and a membranous ovicellular ectooecium (*i.e.*, the endooecium being the exposed skeletal surface). The little-known family Lacernidae Jullien, essentially unused for more than a century, is here considered available for genera with the above suite of characters as well as the presence of complex pore-occlusions in some of the genera.

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In the course of routine examination of the bryozoan collections in the South Australian Museum (SAM), the Western Australian Museum (WAM) and the New Zealand Oceanographic Institute (NZOI), three Recent samples from South Australia, Western Australia and Stewart Island, New Zealand were identified as *Schizoporella insignis* Hincks, 1881. Previously known from Africa (Hincks 1881) and South Australia (MacGillivray 1891), the species differs markedly from *Schizoporella* Hincks, 1877 sensu stricto, and a new genus is here proposed for it. The new genus shares some important features with *Lacerna* Jullien, 1888 and related genera. The group appears to merit recognition as a discrete family within the Schizoporelloidea for which the little-used name Lacernidae Jullien, 1888 is available.

SYSTEMATICS

Order Cheilostomida Busk, 1852
Suborder Ascophorina Levinsen, 1909
Infraorder Lepraliomorpha Gordon, 1989
Superfamily Schizoporelloidea Jullien, 1883
Family Lacernidae Jullien, 1888

Vitrius Parker & Gordon, gen. nov.

Generic diagnosis

Colony encrusting. Zooids glassy, the frontal shield cryptocystidean, with a ring of lateral pores that also encircles the orifice, the porous margin rimmed by gymnocystal calcification. Proximal rim of orifice more or less straight with a distinct sinus. Oral spines and avicularia absent. Ovicell prominent, the endooecium smooth, minutely pitted, the ectooecium entirely membranous; closed by the zooidal operculum. Basal pore-chambers present.

Type species

Schizoporella insignis Hincks, 1881.

Etymology

The generic name *Vitrius* is derived from the Latin adjective *vitreus*, meaning glassy or transparent.

Remarks

Vitrius differs from *Schizoporella* Hincks, 1877 in having glassy zooids, a centrally imperforate frontal shield with conspicuous marginal pores only, a well-developed gymnocystal rim, uncalcified ectooecium, and closure of the ovicell by the zooidal operculum. It is similar to three other schizoporelloidean genera, *Lacerna* Jullien, 1888, *Phonicosia* Jullien, 1888, and *Cribellopora* Gautier, 1957, in important features of the frontal shield and ovicell, though differing in details – *Lacerna* has oral spines, short radii in the frontal-shield pores, scarcely any gymnocyst, and a low rim of ectooecial calcification bordering the ovicell; *Phonicosia* has oral spines, avicularia, reduced gymnocyst, minutely pitted complex pore-closures, and an ovicell not closed by the zooidal operculum; *Cribellopora*, which has one or no oral spines, is characterized by complex pores with complete radii. *Vitrius* is at present monotypic.

Vitrius insignis (Hincks, 1881)
(Figs 1, A-D)

Schizoporella insignis Hincks, 1881: 134, pl. 5, fig. 10; MacGillivray 1891: 82, pl. 9, fig. 8.

Type locality

Africa – no further details given by Hincks.

Material examined

New Zealand: off South Cape, Stewart Island, 55 m, no other data NZOI Z6892; *South Australia:* Boston Bay, southern Eyre Peninsula, no other data (probably collected by O'Halloran *ca* 1890), small ancestrulate colony on seagrass, *Posidonia* sp., SAM L667; *Western Australia:* north side of Beacon Island, Houtman Abrolhos, 25.vi.1985, coll. S. M. Slack-Smith, three small ancestrulate colonies on seaweed, *Sargassum* sp., WAM 632-91.

The sample from Port Wakefield, South Australia listed and figured as *Schizoporella insignis* by MacGillivray (1891) cannot be found in the Museum of Victoria (T. Stranks *in litt.* 12.ix.1991).

Distribution

Stewart Island, New Zealand; South Australia; Houtman Abrolhos, Western Australia; (?southern) Africa.

Description

Colony encrusting, small. Zooids hyaline, 0.38-0.51 × 0.23-0.38 mm the frontal shield with a ring of relatively large simple pores that also encircles the orifice, the porous area bounded by, and set within, a rim marking the edge of the surrounding gymnocyst, with many of the pores occurring partly under the rim; the central area of shield smooth, with a short umbo. Orifice proportionately large in relation to the zooid transversely D-shaped, with a straight proximal rim, and a subcircular sinus that is constricted distally. Opercular tab articulated, and set off from the rest of the operculum by a sclerite. No oral spines or avicularia. Ovicell prominent, closed by the zooidal operculum, the endooecium wholly exposed, more or less smooth, with a minutely pitted area, the ectooecium membranous. Interzooidal communications comprising widely open basal pore-chambers, sealed externally by a membrane, with string of simple pores along each septulum. Ancestrula with a membranous frontal wall, no spines.

Remarks

Thanks to the courtesy of Mr P. J. Chimonides of the Natural History Museum, London, we have been able to examine scanning electron micrographs of the holotype of *Schizoporella insignis*. It is in extremely poor condition, being scarcely recognizable as bryozoan, comprising three separated zooids, one of which is broken and all three covered with debris. Only part of the proximolateral gymnocyst and a lateral septulum of one zooid give a clue as to identity, and these features accord with what we have seen in the Australasian specimens.

The illustrations of Hincks (1881) and MacGillivray (1891) both show a feature of the frontal shield not appreciated by SEM but rather seen in transparency, *i.e.*, a line bisecting the marginal pores. This line is the inner edge of the narrow gymnocyst, which may cover half the area of many or most of the pores. These pores are the simplest among the genera here recognized as lacernid, lacking calcareous radii or other occlusions though a narrow flange-like rim may occur within the pore.

The articulation of the operculum is not uncommon among schizoporelloideans. One genus, *Arthropoma* Levinsen, 1909, is named after this feature, but it is possibly to be expected wherever the zooidal operculum is used also to seal the ovicellular orifice and the broad anterior flap (porta) moves through an arc of some 30°-40° relative to the plane of the tab (vanna) sealing the orificial sinus. The articular sclerite in *Vitrius* can easily be seen in the intact operculum even by reflected light.

As Hincks (1884) pointed out, *Schizoporella insignis* MacGillivray 1883 is a junior primary homonym of *S. insignis* Hincks, 1881 and cannot be retained. It is superseded by its later name *Schizoporella daedala* MacGillivray, 1887 (=*Chiastosella daedala:* Stach 1937).

Discussion

The characters of *Vitrius* appear to ally the genus (at present monospecific) with *Lacerna* Jullien, 1888, *Phonicosia* Jullien, 1888, and *Cribellopora* Gautier, 1957, traditionally included in the family Schizoporellidae Jullien, 1883. *Lacerna* is the type genus of the family Lacernidae Jullien, 1888, which was introduced for it and *Phonicosia*. Jullien's familial diagnosis is brief and rather general – our paraphrase of his French is 'Orifice with the distal rim arched; the posterior rim straight, with a median sinus; the lateral row of pores can occur in two series distally'. With only one hesitant exception, the family name Lacernidae has not, to our knowledge, been used since. Even Calvet (1904), who worked with Jullien (*e.g.*, Jullien & Calvet 1903), included the type species of *Lacerna* in *Schizoporella*. The one exception is Harmer (1957), who posthumously cited the family as comprising only *Lacerna* (which he wrongly considered to include *Buffonellodes)* and possibly *Aimulosia*, but a footnote by A. B. Hastings states that, in unpublished notes, Harmer indicated that he considered merging the Lacernidae in the Schizoporellidae.

Jullien's (1888) diagnosis of the family was trivial, noting features sometimes scarcely useful at the species-level. Furthermore, the type genus and species (*Lacerna hosteensis*) were incompletely described and illustrated, remaining so until very recently. Waters's (1904) apparent redescription was of another species, recently named as *Lacerna watersi* (Hayward & Thorpe 1989). López Gappa (1977) gave a good illustration of fertile *L. hosteensis* and Hayward (1991)

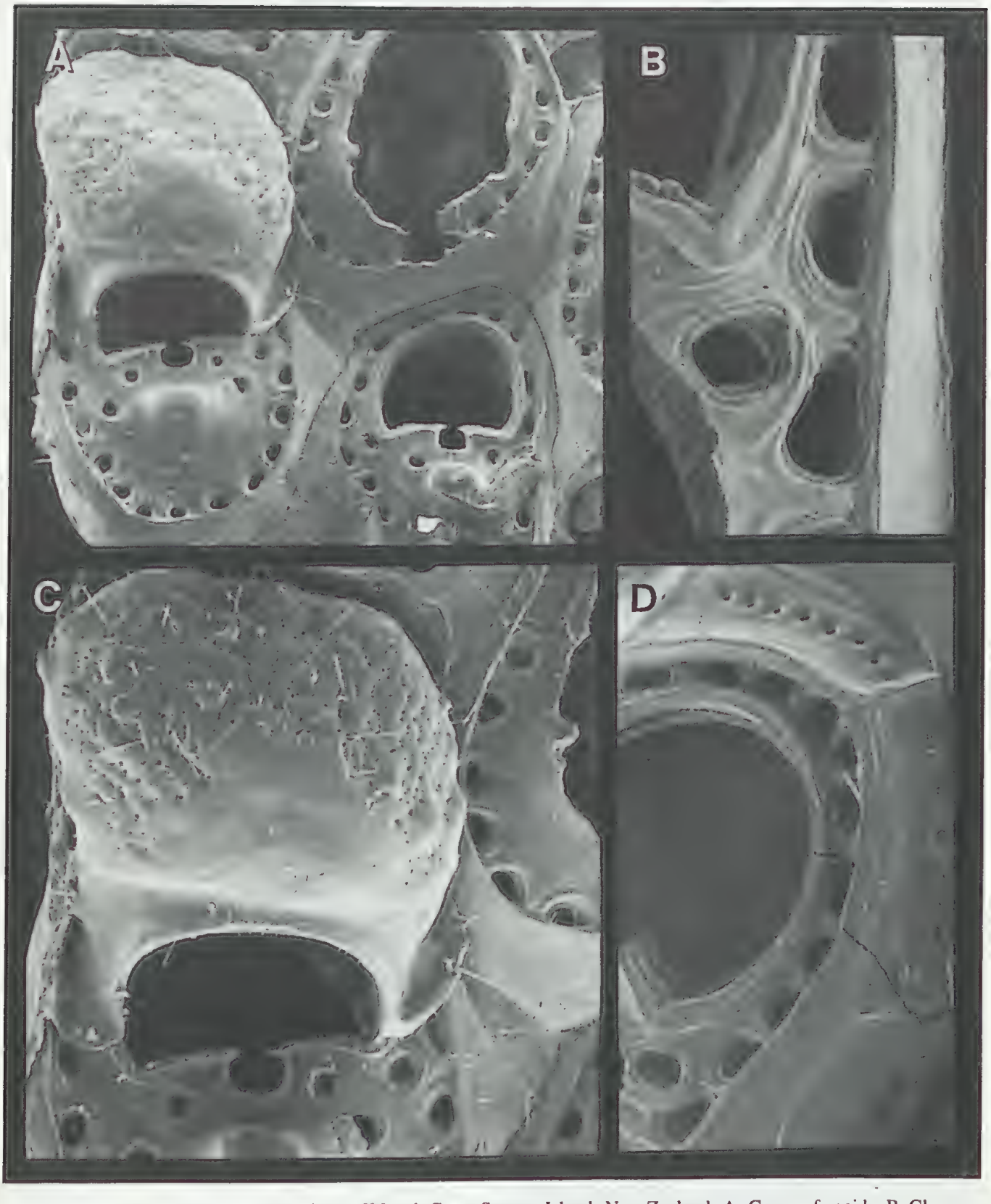

FIGURE 1. *Vitrius insignis* (Hincks), from off South Cape, Stewart Island, New Zealand. A, Group of zooids. B, Close-up of lateral pores at the edge of the gymnocyst adjacent to the orifice. C, Ovicell. D, Widely open pore-chambers distal to the orifice.

examined the type specimen and illustrated the species by SEM. Thus it is now possible to evaluate the distinctiveness of the Lacernidae for the first time. Hayward (1991) did not assign *Lacerna* to a family but, *inter res*, discussed the status of *L. eatoni* (Busk, 1876), noting its general appearance to *Phonicosia* and pointing out that López Gappa (1978) had assigned it to *Cribellopora*. These associations accord with our conclusion that these three genera, with *Vitrius*, are closely related and may be grouped together.

Whatever the eventual constitution or reconstitution of the Schizoporellidae, the lacernid genera *Lacerna, Vitrius, Phonicosia* and *Cribellopora* cannot be regarded as confamilial with *Schizoporella sensu stricto*, and the family Lacernidae Jullien, 1888 is here used to accommodate them. The Lacernidae may be distinguished from the Schizoporellidae *sensu stricto* primarily on the basis of the ovicell, which in the former has only a single calcified layer, the endooecium (the ectooecium being entirely membranous), and which develops in the manner described by Nielsen (1981) for *Fenestrulina* Jullien, 1888. For the Schizoporellidae *s. s.*, the development of the ovicell has, remarkably, not yet been described, but from our preliminary SEM examination of *Schizoporella errata* (Waters, 1878) we conclude that in this family both ovicellular layers are calcified and fused, with the intervening space obliterated. Even if it should be shown that the ectooecium of *Schizoporella s. s.* is membranous, however, significant differences between the Schizoporellidae and the Lacernidae remain, *e.g.* the lacernid ovicell is not overlaid by thick secondary calcification and the hypostegal coelom of the distal zooid. Additional features of the Lacernidae include a mostly centrally imperforate frontal shield that tends not to become thickly calcified but often remains hyaline, a vestigial to proximolaterally well-developed gymnocyst, and marginal pores that can have quite complex occlusions. In *Lacerna* the pores are simple openings early in zooidal ontogeny, but soon develop short simple radii that do not meet in the centre of the pore. In *Cribellopora* the pores develop as in *Lacerna*, but the radii meet and fuse in the centre of each pore, and in some species a fine calcareous mesh may further develop between the radii. In *Phonicosia* a fine mesh without distinct radii occurs, partly or totally occluding the pore-opening when fully developed. *Vitrius* lacks radii or a mesh, having only a narrow circular flange within each pore. Some or all of these pores in these genera are areolar, containing a rosette of transporting cells by which the main body cavity of the zooid (perigastric coelom) communicates with the thin cavity above the cryptocystidean shield (hypostegal coelom) (*see* Banta 1970, 1971, 1973). The presence of significant pore-occlusions, especially in *Phonicosia*, would seem to prevent or severely restrict effective nutrient transport to the hypostegal coelom and perhaps it is significant that frontal budding (which requires such transport) has not been reported in these genera. The apparent lack of secondary calcification may be another possible sign of restricted nutrient transfer.

Insofar as they have basal pore-chambers, *Lacerna, Phonicosia* and *Vitrius* share the same method of budding new zooids — intrazooidal in the terminology of Lidgard (1985). *Cribellopora* lacks basal pore-chambers and budding is zooidal (Lidgard 1985).

Diagnosis of Lacernidae Jullien, 1888

Colony encrusting. Zooids with a relatively thin crypocystidean shield, partly or mostly imperforate centrally, the lateral pores often with complex closures, the frontal area bordered by a vestigial to well-developed proximolateral gymnocyst. Orifice with a distinct sinus, the operculum sometimes articulated. Oral spines and avicularia present or absent. Ovicell with frontally imperforate calcified endooecium and entirely membranous ectooecium. Basal pore-chambers or mural septula present; budding thus intrazooidal or zooidal. Constituent genera: *Lacerna, Phonicosia, Vitrius, Cribellopora.*

Stratigraphic range of Lacernidae

Eocene to Recent. An undescribed species of *Cribellopora* occurs in an Eocene outcrop at Alma, near Oamaru, South Island, New Zealand (DPG, pers. obs.). The earliest records from the published literature are of *Cribellopora latigastra* (David, 1949) from the Miocene of Austria and the Rhône Valley (David & Pouyet 1974; Cook 1985) and *Phonicosia circinata* (MacGillivray 1869) from the Pliocene near Waipukurau, North Island, New Zealand (Brown 1952, as *Arthropoma circinatum*).

Acknowledgments

We should like to express our thanks to the following: Dr P. J. Chimonides, Natural History Museum, London, for scanning the holotype specimen of *Schizoporella insignis* and sending the photographs for examination; Dr P. J. Hayward, University College of Swansea, for commenting on a draft; Ms Diana Jones, Western Australian Museum, for courtesies extended to S.A.P. during his visit to that institution in November 1991 and for subsequently permitting the loan of the WAM *Vitrius* to D.P.G.; Dr H. B. Womersley, State Herbarium of South Australia, for identifying the substrates of the Australian specimens; and Mr T. Stranks, Museum of Victoria, for information on collections in his care.

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THE LIFE OF A 'MUSEUM MAN' — EDGAR WAITE'S DIARIES AS AN HISTORICAL SOURCE

The history of science in Australian museums is a relatively new field. While each of the major metropolitan museums in this country has had its own history published, these accounts have tended to be structured around institutions and personalities, rather than the development of Australian science itself. The gap has been filled to some extent by honours theses and articles published during the 1980s and by the survey works of Home (1988) and Moyal (1976). The history of institutional natural science in South Australia has been summarised by Twidale *et al.* (1986). The most detailed analysis of the history of science in Australian museums has been undertaken by the American historian, S. Kohlstedt. She has surveyed the rich historical materials available in Australian natural history museums and has noted the wealth of primary sources available, ranging from committee reports and scientific manuscripts to correspondence files and memoranda (Kohlstedt 1983, 1984).

Sources for the South Australian Museum's history are as well preserved as those for other Australian museums, contained in the Museum's own archives as well as the State Records repository. Incoming and outgoing correspondence has been retained, particularly from the 1890s onwards, and monthly curators' reports supply vital detail for the earlier period from the opening of the Museum in 1862 until late in the century. These reports, and the Museum Committee's minute books, give an indication of the level of expertise and activity expected of the early Museum Directors. Frederick Waterhouse, for example, combined his skill as a practising naturalist with that of an administrator and an informed advocate on museum practice during the 1860s and 1870s as the Museum struggled to cement its place as an indispensable scientific institution in Adelaide. Edward Stirling (Director from 1888-1913) maintained a prodigious level of activity, publishing on zoological and anthropological subjects, reorganising the Museum's galleries and storage, chairing the Museum Committee meetings, as well as lecturing in physiology at the University of Adelaide. This was not uncommon: the careers of other Australian museum directors such as Gerard Krefft, Frederick McCoy, and Robert Etheridge reflect a similar range of commitment and achievement. It is not surprising to find that these individuals' documentary records consist mainly of their working correspondence and manuscripts, rather than separately maintained journals or notebooks.

Until quite recently, the same was thought to be true of the Yorkshire-born Edgar Ravenswood Waite, who succeeded Edward Stirling as Director of the South Australian Museum in 1913. To the good fortune of museum historians though, Waite's private record of his entire working life in museums has been preserved by his family and has recently become available to historians and scientists. This remarkable source material came to light during research undertaken for Waite's entry in the 'Australian Dictionary of Biography', by John Glover, prior to his retirement as Curator of Fishes at the South Australian Museum. The South Australian Museum already holds a large quantity of Waite's professional correspondence, ledgers containing a record of his voluminous scientific and journalistic publications, and several hundred of his photographs.

Waite's diaries cover not only his South Australian Museum directorship (1913-1928), but also document his career from 1888-1893 as Assistant Curator and Curator of the Leeds Philosophical and Literary Society (later Leeds City Museum), as Assistant Curator in charge of vertebrates at the Australian Museum in Sydney (1893-1905), and as Curator of the Canterbury Museum in Christchurch, New Zealand (1905-1913). Six volumes of the complete set of 77 diaries are missing at the time of writing, but may well be located among family members. The diaries have been lodged by the Waite family with the South Australian Museum for copying, pending their permanent transferral there at a future date. The immediate intention is to have the diaries copied on microfiche, with copies available either in that, or in printed form,

The diaries comprise small black notebooks of about 100 pages. The daily entries, about two pages of Waite's neat ink handwriting, are interspersed with occasional newspaper clippings or an ephemeral document, photograph or sketch. With few exceptions, each day of Waite's working life is recorded in at least cursory detail. Although obviously intended as a personal record, the diaries give little more than an outline of Waite's home life with his wife Rose and their only child, Claude. He devotes more time, in contrast, to recording the vagaries of his succession of Douglas motorbikes, which served him well for many years despite scrapes and mishaps. Waite's hobbies as a flautist, photographer and aquarium keeper lend further colour.

While the diaries are generally written with the detachment of an Edwardian scientist, Waite gives occasional vent to the frustrations and rewards of his special position in Adelaide's scientific and cultural life. As with other museum directors, his relationship with members of his controlling committee was not always smooth. Despite this, he had little difficulty in adjusting to his successive working environments. As his biographer, John Glover (1990), has written:

> Imposing but gentle, with a dry sense of humour, he was held in affection and esteem by all who knew him well. ['Australian Dictionary of Biography', vol. 12: 349]

The diaries record some important successes in Waite's negotiations with the Museum Committee, such as their approval (in September 1917) of his suggestion to launch the *Records of the South Australian Museum.*

Waite published a greater range and number of scientific papers than any of his Australian counterparts: a total of 175 papers on Australian and New Zealand subjects during the 35 years from his arrival in Sydney until his death. This number of publications reflects Waite's broad interest in the taxonomy of zoological species. Some of the publications, such as 'The Fishes of South Australia' (Adelaide, 1923) or 'The Reptiles and Amphibians of South Australia' (Adelaide, 1929), remained standard texts for many years.

It might be expected that Waite's diaries would add little to the record of his scientific achievements, and that their primary value to historians might lie only in their anecdotal interest. Certainly this may apply to aspects of Waite's natural science research and collecting activities, such as the fundamental details of the place, date and circumstances of collection. Nevertheless, Waite's succinct first-hand accounts supply an historical depth, otherwise unobtainable, to each of his scientific excursions – ranging from his role on Sir Douglas Mawson's first sub-Antarctic cruise in 1912, his retrieval of whale skeletons and dredging excursions in South Australian waters, to his leadership of the South Australian Museum's collecting expeditions to the north-east of the state in 1916 and to New Guinea, New Britain and New Ireland in 1918.

The ethnographic detail contained in these diaries provides an exciting new insight into the South Australian Museum's anthropological history. Waite's leadership of the 1916 Strzelecki Creek expedition and the 1918 North-West Pacific Islands expedition gave him an opportunity to extend his expertise even further than his broad base in natural science. The 1916 expedition allowed only passing contact with Aboriginal people and Waite's published comment, that 'there is little of interest to write about the aboriginals', might suggest that he had exhausted his potential as an ethnographer. In contrast though, Waite's 1918 expedition to the Pacific yielded almost six tons of natural science and ethnographic specimens. Hale's published history of the South Australian Museum (1956) is vague as to the exact reasons for this expedition, referring only to the fact that Australia's occupation of captured German territory in the Pacific made such an expedition possible. Waite's diary entry for 1 May, 1918, makes Sir Edward Stirling's contribution more apparent:

> Stirling has been very keen on getting Ethnological material from (late) German Territory & he proposed an expedition to New Guinea, New Britain & Solomons. This was agreed to: the director & A.C Davis, late administrator of the natives in New Ireland, to form the party. If the Board approves, I am likely to realise one of my most fervent dreams; to visit the land of the Bird of Paradise & other groups I had not dared to dream of . . .

Waite and Davis made extensive collections of natural history on this expedition, which travelled through Papua New Guinea, New Britain, New Ireland and nearby islands from 31 May to 1 September, 1918. While he paid only brief attention to the structures of social life and ritual, Waite nevertheless distinguished himself as a careful recorder of ethnographic detail. His brief account of the use of a spiders' web net for fishing, on the small island of Mapua, provides an example:

> . . . the web is carried wound across the limbs of a forked stick & when used is unwound & attached to a line like a bait: the teeth of the fish are entangled in the web. As far as I could make out it is garfish that are taken this way (16 July 1918).

Waite and Davis carefully labelled each of their purchases and specimens as they were obtained, and most of these details were subsequently transferred to the South Australian Museum's Anthropology and Natural Science Registers. Additional information may be gleaned from the diaries, nevertheless. This may range from specific detail, such as prices paid for a shark float (two pounds) and a pig net (one pound) in a remote New Ireland village on 8 July 1918, to the anecdotal: on the island of Tabar, Waite became known as 'master belong firewood', for his acquisition of funerary malanggan masks which would ordinarily have been burnt (9 August 1918). The background to these ethnographic transactions is crucial to an adequate understanding of the artefacts, many of which have been on display in the Museum's Pacific Gallery or in storage for the past seven decades.

Like his predecessor at the South Australian Museum, Edward Stirling, Waite possessed the facility of making useful contacts wherever he travelled. Although he and Davis each made sizeable ethnographic collections on this expedition, these were outnumbered by others which Waite was able to purchase from other individuals such as Whiteman, Hunter, Cummins, Eugelke, Goedecke-Meyer, Petterson and Gotham, who had established themselves as traders and officials throughout the region. These transactions, as well as individual purchases and exchanges with native people, are all recorded in the diaries.

The discovery of a previously unknown or unused primary historical source is always an exciting event, not least for the light which it may cast, in turn, on other documentation. In Waite's case, it will enable a thorough attempt to be made at cataloguing his extensive collection of photographs, already held in the

South Australian Museum. These depict many aspects of his museum career, particularly field expeditions. More generally though, the Waite diaries provide an opportunity for the re-evaluation of the place of Australian and New Zealand museums within their local scientific and cultural milieu, at a time when colonial science was strongly asserting itself in relation to its British and European origins.

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FIRST REPORT OF THE ENIGMATIC METAZOAN *ANOMALOCARIS* FROM THE SOUTHERN HEMISPHERE AND A TRILOBITE WITH PRESERVED APPENDAGES FROM THE EARLY CAMBRIAN OF KANGAROO ISLAND, SOUTH AUSTRALIA

B. MCHENRY & A. YATES

MCHENRY, B. & YATES, A. 1993. First report of the enigmatic metazoan *Anomalocaris* from the southern hemisphere and a trilobite with preserved appendages from the Early Cambrian of Kangaroo Island, South Australia. *Rec. S. Aust. Mus.* 26(2): 77–86.

Recently discovered fossils from the Early Cambrian, Emu Bay Shale of Kangaroo Island include a new and undescribed species of the enigmatic metazoan *Anomalocaris* Whiteaves, 1892, and a cephalon with preserved antennae of the trilobite *Redlichia takooensis* Lu, 1950. The site is recognised as the first occurrence of *Anomalocaris* in the southern hemisphere and the discovery of this animal supplies a possible predator capable of inflicting injuries to the large trilobites reported from the locality. The trilobite specimen is not only the first from Australia with preserved appendages but is the only redlichiid known to exhibit this feature.

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Enigmatic 'soft-bodied' faunas have been reported from many Cambrian localities (Conway Morris 1989). Exceptionally well preserved fossils occur in the lower part of the Early Cambrian Emu Bay Shale, exposed East of the mouth of Big Gully, 3km West of White Point on the northern coast of Kangaroo Island, South Australia (see Fig. 1). At this site lightly skeletonised and soft parts are presumed to be preserved as sheets of fibrous calcite (Glaessner 1979) although they have never been analysed. The fauna described so far from this locality consists of the annelid worms *Paleoscolex antiquus* Glaessner 1979, *Myoscolex ateles* Glaessner 1979 and *Vestustivermis planus* Glaessner 1979, the trilobites *Hsuaspis bilobata* (Pocock 1964) and *Redlichia takooensis* Lu 1950 and the possible phyllocarid crustaceans *Isoxys communis* Glaessner 1979 and *Tuzoia australis* Glaessner 1979. The Emu Bay Shale and its fauna have been suggested to be an approximate equivalent to the *Pararaia janeae* trilobite zone of the South Australian Cambrian sequence. Although correlations between the Cambrian sequences of Australia and the rest of the world are not easy, it has been tentatively assigned on the basis of trilobites, archaeocyatha, molluscs and 'small shelly' fossils to the Late Botomian Stage of the Siberian Scale for the Early Cambrian (520–530 Myr BP) (Bengston *et al.* 1990).

Reports of indiscriminate and destructive excavation at this site by commercial collectors in early 1991 prompted an examination by one of us (A.Y.), to assess the amount of material removed and to make a representative collection for the South Australian Museum. Among the important discoveries made during this field trip were that of remains of what

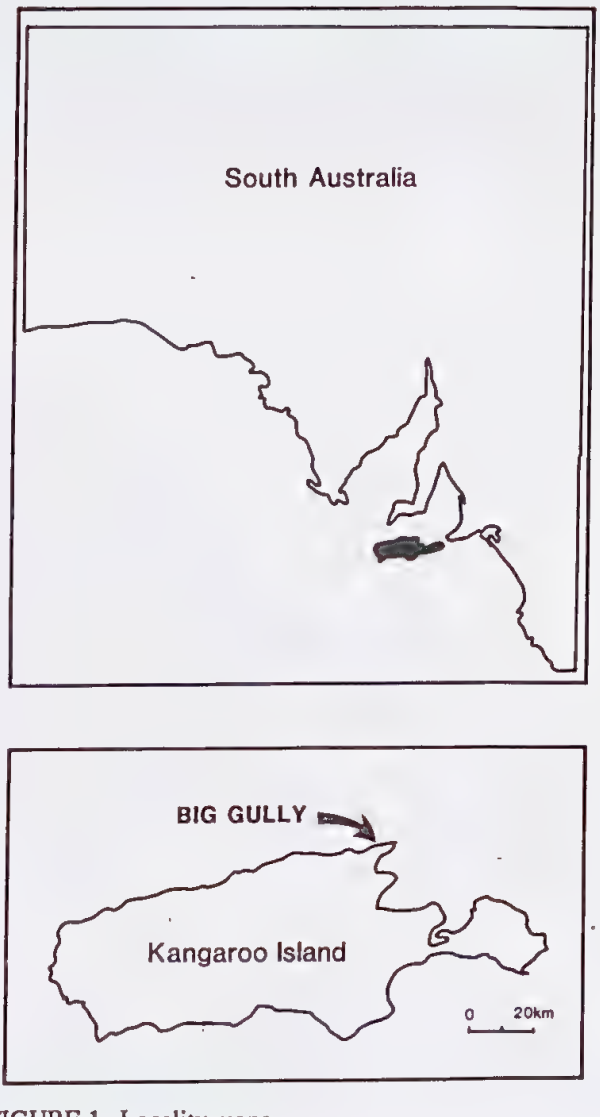

FIGURE 1. Locality maps.

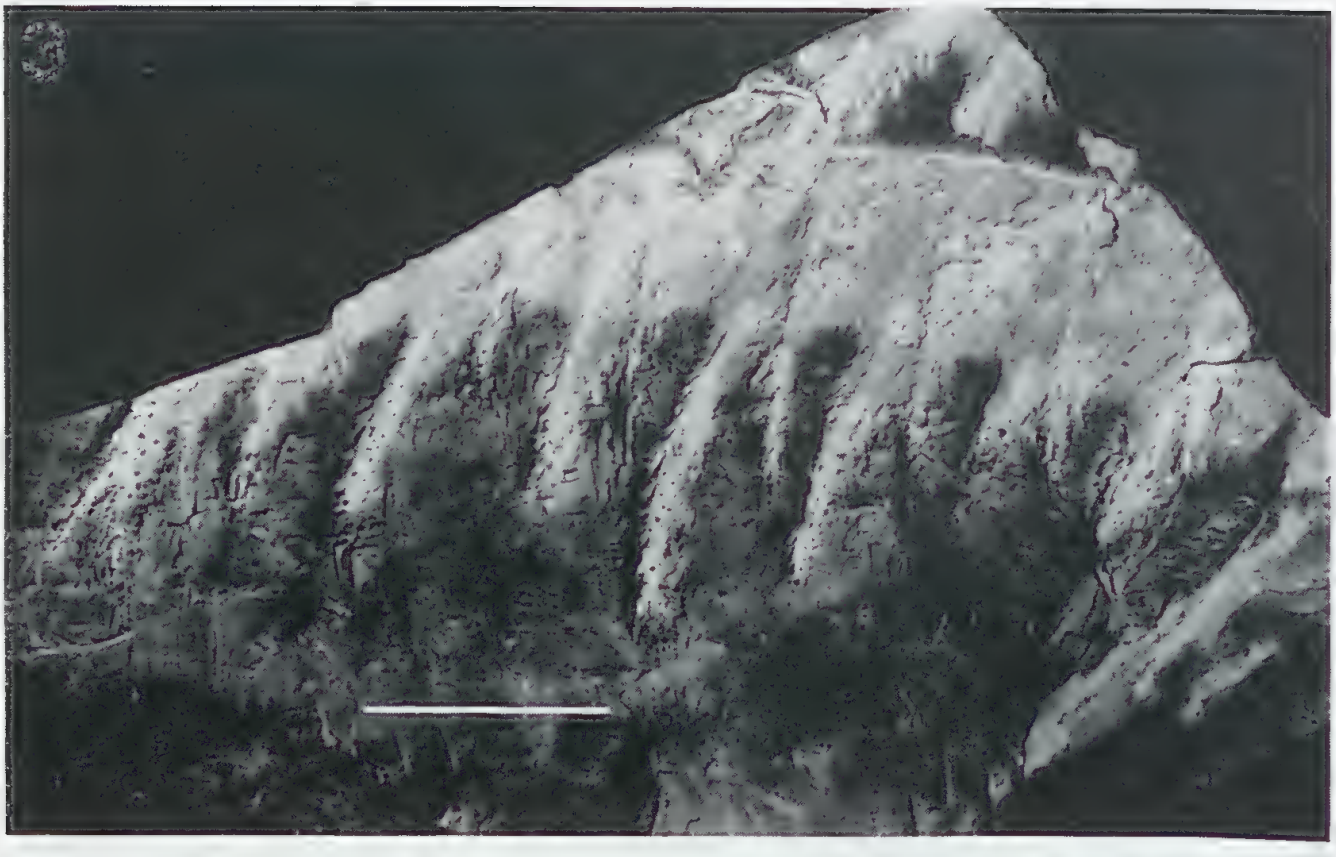

FIGURE 2. Cephalic appendages of *Anomalocaris* sp. from the Early Cambrian Emu Bay Shale, Big Gully, Kangaroo Island, South Australia (SAMP31953 A and B). Visible are two partial appendages (specimens A and B) with ventral spines extending downwards. A partial cephalon of the trilobite *Hsuaspis bilobata* (Pocock, 1964) is located between the two appendages. Scale bar 20 mm.

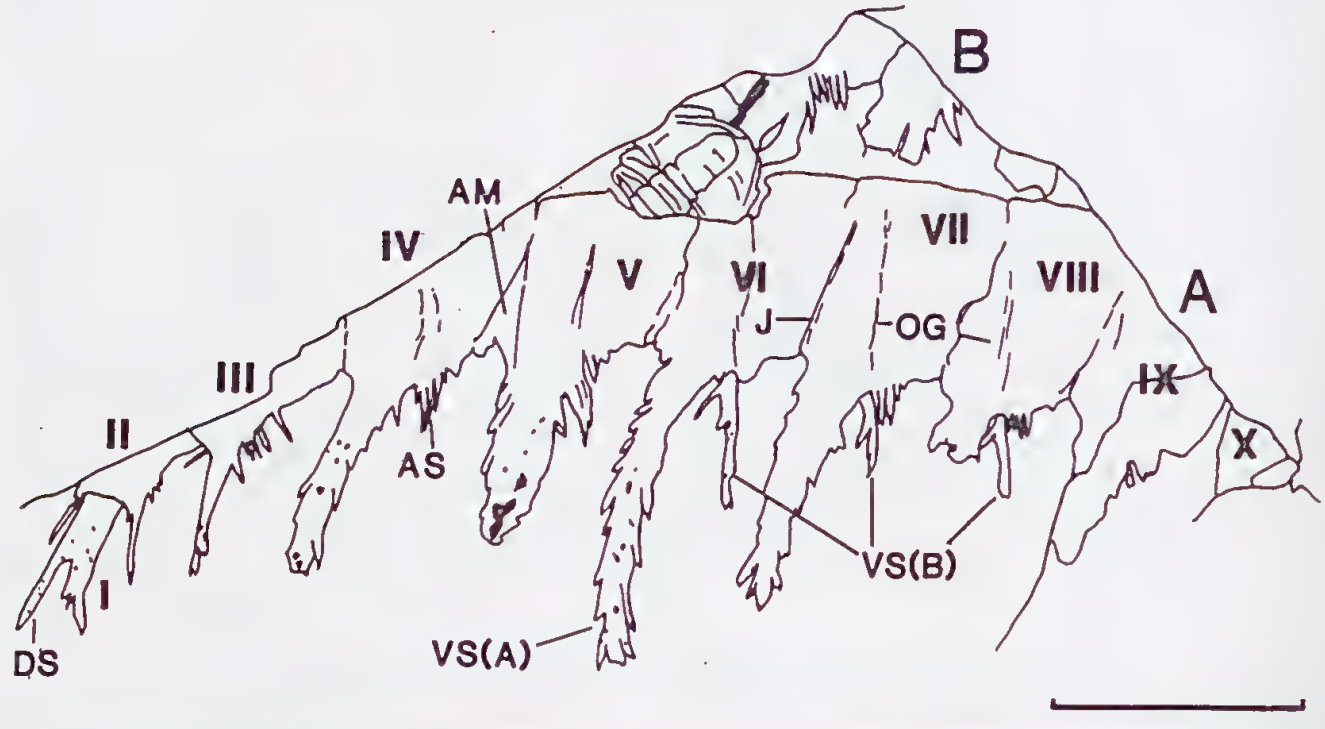

FIGURE 3. Line drawing of cephalic appendages of *Anomalocaris* sp. from Kangaroo Island, same specimens as Figure 2. Segment numbers I - X of specimen A are preserved but the base of the appendage is missing. Only a small fragment of specimen B is visible. The dorsal spine (DS) on specimen A is present as are ventral spines for both specimens, VS(A) and VS(B). Joints between the segments (J) are identifiable as are the 'oblique grooves'(OG) attributed to the crushing of specimen A onto B. Scale bar 20 mm.

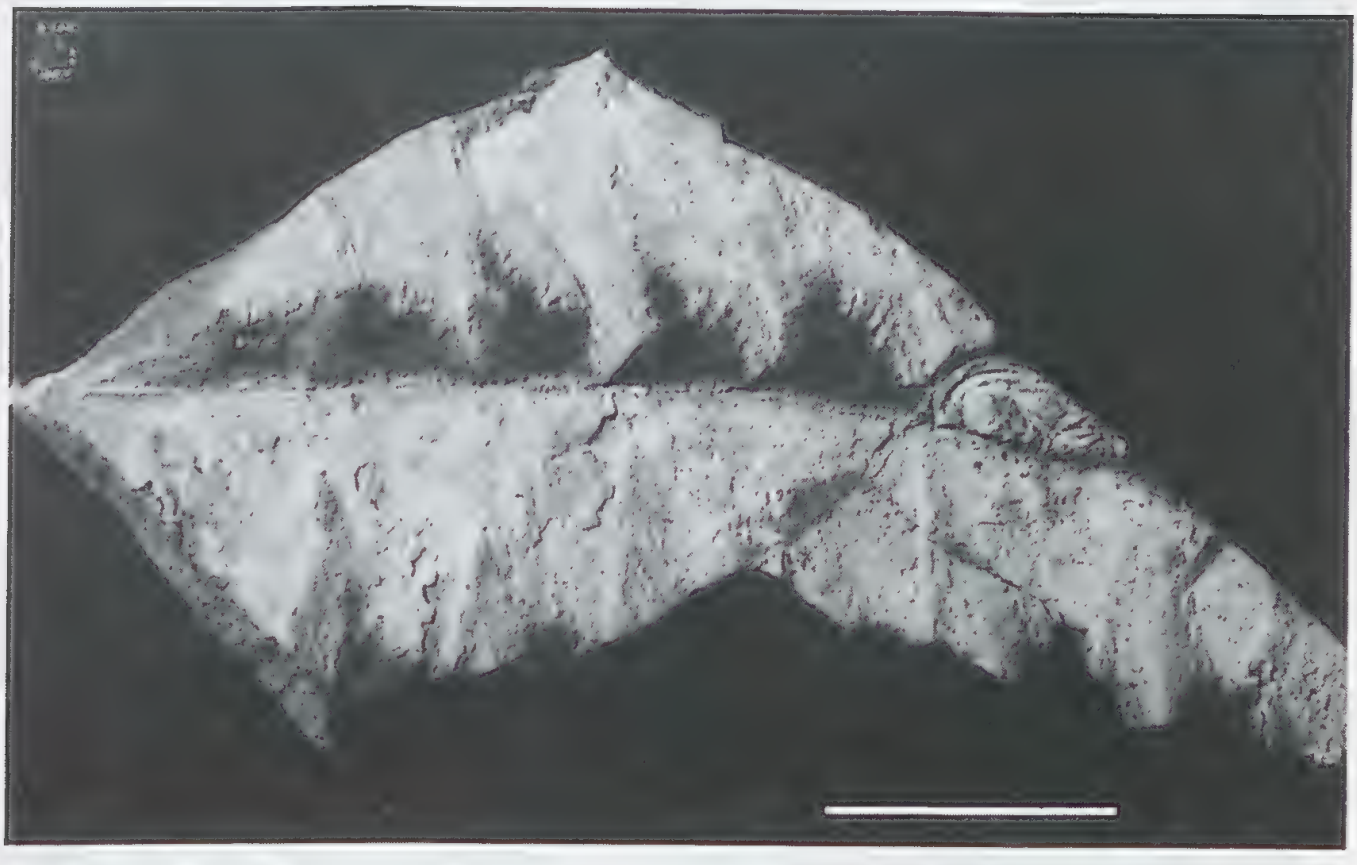

FIGURE 4. Cephalic appendages of *Anomalocaris* sp. from the Early Cambrian Emu Bay Shale, Big Gully, Kangaroo Island, South Australia (SAM P31954 A and B). Counterpart slab of SAM P31953. Visible are two partial appendages (specimens A and B) with ventral spines extending downwards. A partial cephalon of the trilobite *Hsuaspis bilobata* (Pocock, 1964) is located between the two appendages. Scale bar 20 mm.

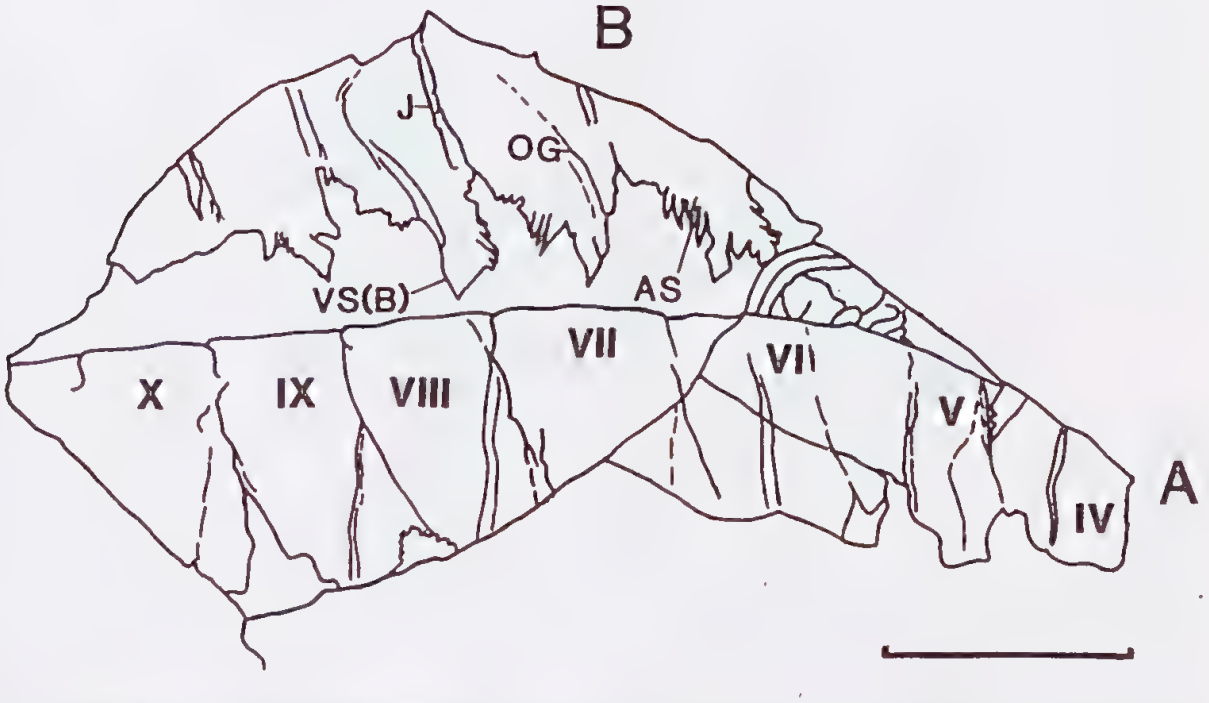

FIGURE 5. Line drawing of cephalic appendages of *Anomalocaris* sp. from Kangaroo Island, same specimens as Figure 4. Segment numbers IV - X of specimen A are preserved but the ventral spines are missing. Specimen B is more completely represented than on SAM P31953 and both the ventral spines, VS(B), and auxiliary spines, AS, are visible. Joints between the segments (J) are also identifiable. Scale bar 20 mm.

FIGURE 6. Partial cephalic appendage of *Anomalocaris* sp. from the Early Cambrian Emu Bay Shale, Big Gully, Kangaroo Island, South Australia (SAM P51955). The small clusters of auxiliary spines which occur at the base of the ventral spines of the appendage and are unique to the Kangaroo Island specimens are clearly visible. Scale bar 20 mm.

FIGURE 7. Line drawing of partial cephalic appendage of *Anomalocaris* sp. from Kangaroo Island, same specimen as Figure 6. The group of auxilliary spines (AS) at the base of the ventral spines (VS) are indicated, as well as areas of possible arthrodial membrane (AM) at the joints (J) between the segments. Scale bar 20 mm.

appears to be a new species of the enigmatic metazoan *Anomalocaris* Whiteaves, 1892, and a specimen of the trilobite *Redlichia takooensis* Lu, 1950, with preserved appendages.

All specimens were found in loose blocks that had been left by the collectors, so precise stratigraphic information is not yet available. There are two main areas of exposure at the site, one in the sea-cliff and the other on the wave cut platform (Glaessner 1979). The specimens of *Anomalocaris* originated from the wave cut platform while the trilobite specimen cannot be placed as it was part of the previous collectors' discard pile. These specimens are now housed in the palaeontological collections of the South Australian Museum (SAM P31953–P31957). Here we report and briefly describe these new specimens. Detailed descriptions of the species are the subject of current research and will be published in the future.

Description Of Material

Anomalocaris sp.

The first specimens to be reported in Australia of *Anomalocaris* are three large curving, segmented cephalic appendages. These appear to belong to an as yet unnamed species. They occur on three slabs (SAM P31953, P31954, P31955 (Figs 2–7), the first two slabs being a part and counterpart set. The more complete specimens are two appendages lying parallel and partly overlapping each other and occur on the part/counterpart slabs (P31953A and B, P31954A and B (Figs 2, 4). The other specimen (P31955) is a single fragment of a lone appendage (Fig. 6). The most complete specimen measures 107 mm in length and 19 mm in width at the proximal end, tapering to a point distally (Figs 2, 3). This appendage has the remains of 10 preserved segments including the terminus, but is incomplete and almost certainly possessed more segments as in other anomalocarids. In this description, because preservation is incomplete, segments on the appendages have been numbered from the terminus for expediency. Thus the terminating segment has been numbered I, the penultimate II, and so on. Each segment bears ventrally at its distal end a long proximally curving spine with the most complete one preserved (on segment VI of P31953A) being 3 mm wide and 26 mm long, which is longer than the appendage is deep (Figs 2, 3). There is no evidence that these ventral spines were paired. The smaller spines seen lying along the ventral spines of segments VI–VIII of P31953A are the tips of the ventral spines of P31953B (Figs 2, 3).

The ventral spines bear many (between 1 and 9) small auxiliary spines of approximately 1–2 mm in length, particularly along their distal borders although the actual numbers of these auxiliaries present is probably a product of preservation. On the proximal side of the base of the main spines, there is a group of approximately 4 closely spaced auxiliary spines 3–4 mm long. These are present on all specimens but are particularly well preserved on the first two ventral spines of P31955 (Figs 6, 7).

Single dorsal spines, 8 mm in length, are present on segments I and II of P31953A (Figs 2, 3). The dorsal area of segments III and IV is missing whereas the dorsum of all other segments is smooth and lacking any spines. The fibrous calcite sheet is noticeably thinner around the ventral segment boundaries. This is reflected by a reddish colouration in P31955 and is thought to possibly represent areas of arthrodial membrane previously described in specimens of *A. canadensis* (Briggs 1979) (Figs 6, 7). Oblique grooves can be seen to run through the segments of both appendages on P31953. Since there are none of these grooves present on P31955, they are thought to represent post mortem features created by compaction: at least some of the grooves on P31953A are attributable to the appendage being crushed into the underlying spines of P31953B (Figs 2, 3).

Mention should be made of a problematic radially lobate fossil collected with the *Anomalocaris* material (SAM P31956 (Fig. 8). This specimen does bear some resemblance (though perhaps superficially) to the mouth of *Anomalocaris* (Fig. 9). In the Burgess Shale the mouth occasionally occurs separately from the anomalocarid body (Whittington & Briggs 1985) and was originally described by Walcott in 1911 as a medusoid, *Peytoia*. As with an *Anomalocaris* mouth, it consists of a series of groups of narrow lobes separated by single wider lobes. Unlike *Anomalocaris*, however, the narrow lobes appear to be transversely ribbed and this form has no central opening. We believe this may be due to the specimen being preserved in a closed state. Whittington & Briggs (1985) have reported the anomalocarid mouth as being recognized in a variety of orientations and states of closure but as this specimen is badly eroded a confident interpretation cannot be made without further material.

Trilobite Appendages

The single specimen of *Redlichia takooensis* Lu, 1950, with preserved appendages (SAM P31957) consists of an obliquely distorted, two thirds of a cephalon that measures 117 mm in width (Figs 10, 11). Protruding from the anterior border of the cephalon are what appear to be two short antennae which are 24 mm and 30 mm in length respectively, tapering from a maximum measured width of 3.5 mm to a point. Segment borders can be seen on the right antenna where the calcite replacement has flaked away leaving a mould (Fig. 12). There appear to be 11–13

FIGURE 8. Possible mouth of *Anomalocaris* sp. from the Early Cambrian Emu Bay Shale, Big Gully, Kangaroo Island, South Australia (SAM P51956). Scale bar 10 mm.

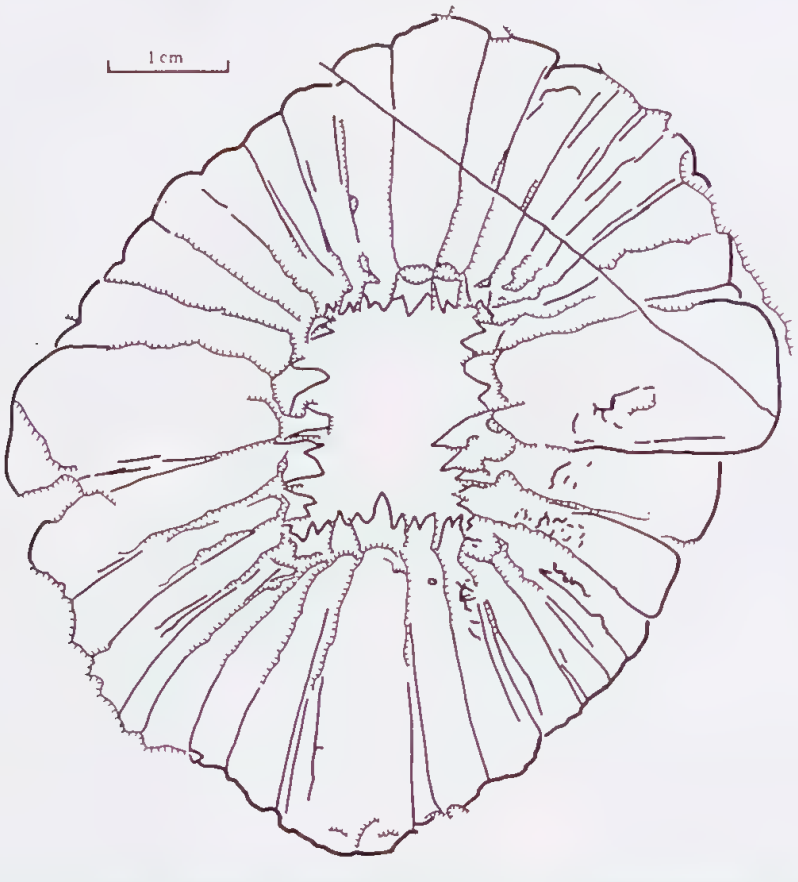

FIGURE 9. Composite drawing of the mouth of holotype of *Anomalocaris nathorsti* (Walcott, 1911) from the Middle Cambrian Burgess Shale 'Phyllopod Bed', Stephen Formation, 4.8 km North of Field, British Columbia (United States National Museum no. 57538). (From Whittington and Briggs 1985, Figure 60).

FIGURE 10. Partial cephalon of *Redlichia takooensis* Lu, 1950, from the Early Cambrian Emu Bay Shale, Big Gully, Kangaroo Island, South Australia (SAM P51957). The two segmented antennae can clearly be seen protruding from under the anterior border of the cephalon. Scale bar 20 mm.

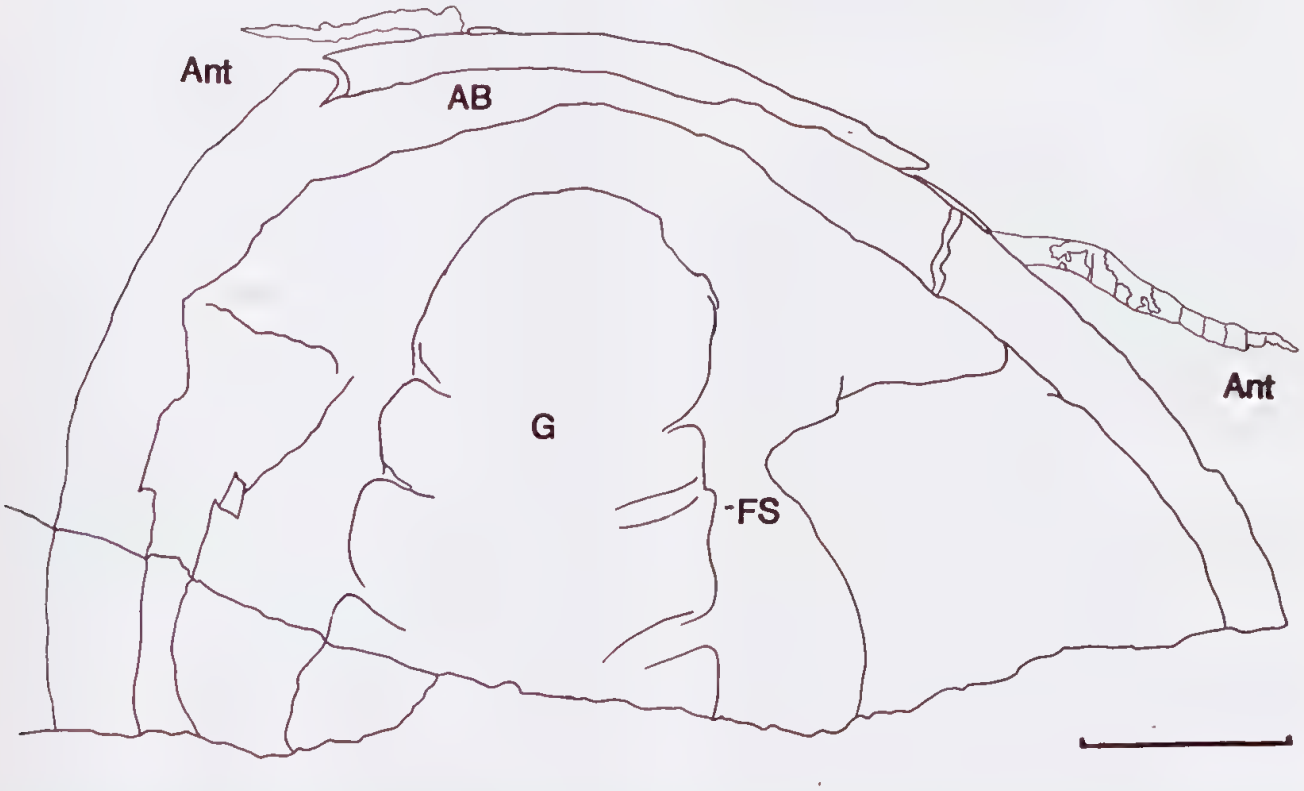

FIGURE 11. Line drawing of partial cephalon of *Redlichia takooensis* Lu, 1950, from Kangaroo Island, same specimen as Figure 10. The anterior border (AB), facial suture (FS) and glabella (G) can be readily delineated as well as the two protruding segmented antennae (ANT). Scale bar 20 mm.

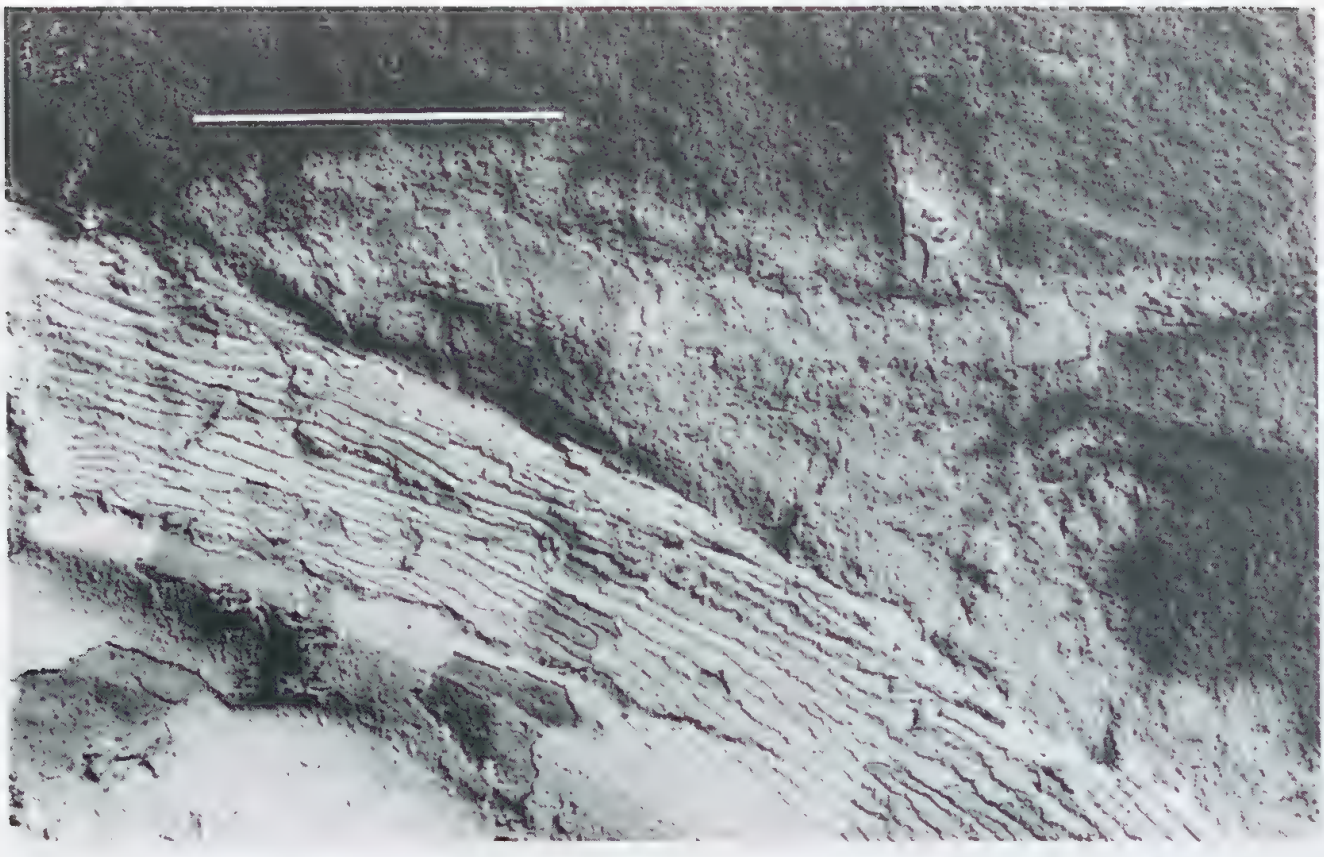

FIGURE 12. Enlargement of anterior border of cephalon of *Redlichia takooensis* Lu, 1950, same specimen as Figure 9, showing right antenna. Scale bar, 10 mm.

segments visible on the section of the antenna which protrudes from under the cephalon (Fig. 11). This is the first known Australian trilobite to have appendages preserved and these are also the first known redlichiid appendages to have been discovered.

Discussion

Our specimens of *Anomalocaris* share some characteristics with *A. canadensis* Whiteaves 1892 and some with *A. nathorsti* (Walcott 1911) but also possess features not found in the described species of this genus. As in *A. canadensis* there are no lateral spines, the dorsal spines are restricted to the terminal segments and the cephalic appendage is not strongly recurved. *Anomalocaris nathorsti* has unpaired ventral spines which are longer than the segments are deep and possesses numerous small auxiliary spines which do not alternate in length. The group of auxiliary spines occurring at the base of the main ventral spines is unique to the South Australian species.

Anomalocaris has been interpreted as a large Cambrian predator (Whittington & Briggs 1985, Briggs & Whittington 1985) although the theory has been raised that some anomalocarids may have been filter feeders. Forms such as *A. nathorsti* and *Cassubia infercambriensis* (Lendzion 1975) possess broad, blade-like spines which contact each other and form a graticule, suggestive of an arrangement analogous to the filtratory feeding appendages of some living crustaceans (Dzik & Lendzion 1988). To our knowledge the species from Kangaroo Island is similar to *A. canadensis* and *A. pennsylvanicus* Resser, 1929, and does not have this arrangement of spines. It therefore should not be included amongst the possible detrital feeders.

Except for the articulated material in the Burgess Shale (Whittington & Briggs 1985) and a single other specimen (Briggs & Robison 1984), remains of *Anomalocaris* occur only as isolated appendages. Anomalocarids have been reported from the Early Cambrian of British Columbia (Resser 1929, Briggs 1979), Pennsylvania (Resser & Howell 1938, Briggs 1978), California (Mount 1974, Briggs & Mount 1982), NE Poland (Dzik & Lendzion 1988), southern China (Chen *et al.* 1991, Hou & Bergstrom 1991), and from the Middle Cambrian of Utah (Briggs & Robison 1984, Conway Morris & Robison 1982, 1986, 1988) and several localities in British Columbia (Fritz 1971, Collins *et al.* 1983, Whittington & Briggs 1985). The discovery of the Kangaroo Island specimens extends the range of this group of animals to the current southern hemisphere, showing that they had a world-wide distribution in the Early Cambrian (Fig. 13).

Reported specimens of redlichiid trilobites from the Emu Bay Shale possess what appear to be healed injuries which had been inflicted by an unknown

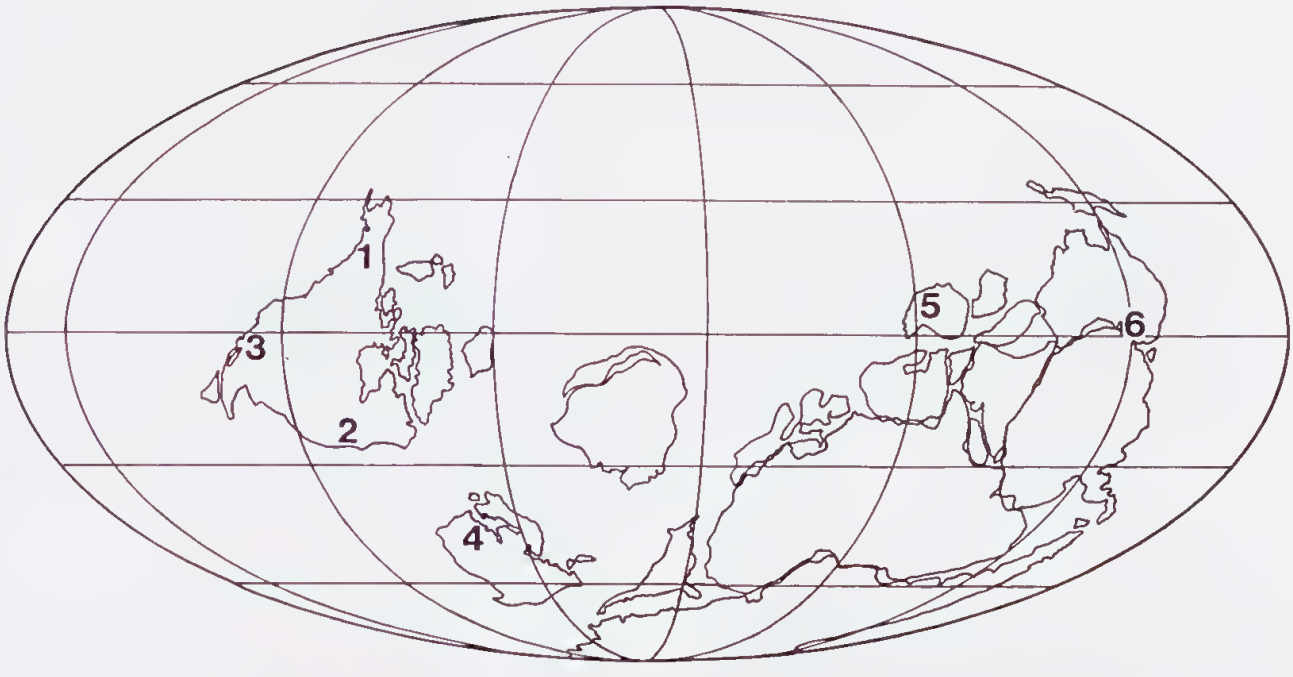

FIGURE 13. Reconstruction of continental positions during Early Cambrian (520–530 Myr BP; after McKerrow *et. al.* 1992) showing known occurrences of *Anomalocaris*. 1, British Columbia; 2, Pennsylvania; 3, California; 4, NE Poland; 5, Southern China; 6, South Australia (see text).

predator (Conway Morris & Jenkins 1985). It was concluded that the predator might have been an undiscovered metazoan or that the trilobites might have been cannibalistic. We consider it to be very probable that at least some of these injuries might have been inflicted by *Anomalocaris* sp., an occurrence that has been suggested by similar marks found on trilobites from the Middle Cambrian Burgess Shale locality at Mount Stephen in Canada (Rudkin 1979, Whittington & Briggs 1985, Briggs & Whittington 1985), middle Cambrian strata in Utah (Vorwald 1982) and the lower Cambrian of California (Alpert & Moore 1975). The healed injuries on the Kangaroo Island specimens include missing pleural tips as well as excisions into the distal portions of the pleura. Whittington & Briggs (1985) suggested that *Anomalocaris* most probably fed by capturing prey with the cephalic appendages and then used these to draw the food to the ventrally placed mouth. It is possible that the observed injuries in the Kangaroo Island redlichiids represent the results of an unsuccessful attack by an anomalocarid attempting to bite a struggling trilobite, which was rewarded for its efforts by eventual escape from the grasp of the predator's cephalic appendages.

These newly reported fossil specimens suggest that the South Australian locality bears a closer resemblance to the famous Burgess Shale of British Columbia than was previously recognised. Further studies at this site will contribute to an understanding of how these exceptional preservations have occurred and help shed some light on the current problems associated with interpreting this world-wide fauna (Gee, 1992).

Acknowledgments

The authors wish to thank Jim Gehling, University of South Australia, for helpful suggestions with the manuscript. We are indebted to Jenni Thurmer for invaluable assistance with the preparation of the figures and Gino Smidero, University of South Australia, for photographing the specimens. We thank the two anonymous referees whose comments greatly improved the final paper and Derek Briggs, Harry Whittington and the Royal Society, London, for permission to reproduce the line drawing (Fig. 10) of the *Anomalocaris* mouth from the 1985 description of the genus.

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MOLLUSC TYPE SPECIMENS IN THE SOUTH AUSTRALIAN MUSEUM. 5. GASTROPODA: CYPRAEOIDEA

K. L. GOWLETT-HOLMES & W. ZEIDLER

GOWLETT-HOLMES, K. L. & ZEIDLER, W. 1993. Mollusc type specimens in the South Australian Museum. 5. Gastropoda: Cypraeoidea. *Rec. S. Aust. Mus.* 26(2): 87–103

The South Australian Museum collection of Cypraeoidea types contains 66 species, subspecies or varieties of the families Cypraeidae (55 taxa), Ovulidae (3 taxa) and Triviidae (8 taxa). Most of these are foreign, with 34 from Fiji alone, three from New Caledonia, two from the Hawaiian Islands and one taxon each from Borneo, Madagascar, Papua New Guinea and Timor. The 17 Australian taxa are from Western Australia and South Australia. Six taxa are without any locality data.

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The following catalogue of type specimens of the superfamily Cypraeoidea held in the South Australian Museum (SAM) is part of an ongoing program to provide such information as an aid to future taxonomic studies.

The South Australian Museum's collection of Cypraeoidea has been acquired by a variety of means. The bulk of the historical material was collected, or otherwise obtained, by Sir Joseph Verco around the turn of the century. As cowries and their allies have always been very collectable items, many additions have been made to the collections by donation or by purchasing other peoples' collections. One of the most significant of these was the A. F. Kenyon Collection, which the Museum purchased early this century. Mrs Kenyon accumulated a relatively large collection and acquired many types, particularly of cowries and cones. Cowries were her special interest, and she described a number of new species and varieties, the types of which are represented in the collections, although none of these species are now considered valid. Apart from Kenyon (1897, 1898, 1900 & 1902), the other major addition to the type collection was by Steadman and Cotton (1943, 1946), who described a number of varieties and subspecies, mainly from Fiji, only one of which may now be valid.

The Cypraeoidea type collection represents 66 species, subspecies or varieties of the families Cypraeidae (55 taxa), Ovulidae (3 taxa) and Triviidae (8 taxa). Most of these are foreign, with 34 from Fiji alone. Other foreign specimens are from Borneo (1), Hawaiian Islands (2), Madagascar (1), New Caledonia (3), Papua New Guinea (1) and Timor (1). Australian specimens are from Western Australia (W.A.) (11) and South Australia (S.A.) (6). Six taxa are without any locality data. All of the types except for some paratypes of *Crenavolva cruenta* Gowlett-Holmes & Holmes, 1989, are dry and in most cases are only represented by the shell.

In the following list, species are listed alphabetically according to their names at the time of description. Current synonymies are according to Burgess (1985) for the Cypraeidae, Cate (1973) for the Ovulidae, and Cate (1979) for the Triviidae, unless otherwise noted. Higher classification is according to Vaught (1989).

Some of the early mollusc taxonomists did not indicate type specimens and often their descriptions were based on more than one specimen. In those cases where no holotype was designated and the description was clearly based on more than one specimen, the type series held in SAM is considered syntypic (Article 73(b), ICZN). Where the description was clearly based on a single specimen, this specimen is considered to be a holotype, even if it was not clearly designated as such (Article 73(a), ICZN).

We have illustrated selected taxa, mainly those which have not been illustrated adequately previously, or were not listed by Burgess (1985), or those whose present taxonomic status is doubtful

Superfamily CYPRAEOIDEA

Family CYPRAEIDAE

Genus *Arabica* Jousseaume, 1884

Arabica eglantina momokiti Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 327.
= *Cypraea eglantina* Duclos, 1833.

Holotype: D14162, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.

Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Arabica scurra vono Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 328.
= *Cypraea scurra* Gmelin, 1791.
Holotype: D14163, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention a further eleven specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Basilitrona* Iredale, 1930

Basilitrona isabella cavia Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 326.
= *Cypraea isabella* Linnaeus, 1758.
Holotype: D14161, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Basilitrona isabella lemuriana Steadman & Cotton, 1946
Rec. S. Aust. Mus. 8(3): 507.
= *Cypraea isabella* Linnaeus, 1758.
Holotype: D14516, adult specimen, from Madagascar, collector and date of collection unknown.

Genus *Bistolida* Cossman, 1920

Bistolida fluctuans nandronga Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 318–9.
= *Cypraea stolida* Linnaeus, 1758.
Holotype: D14148, adult specimen, from Nadroga, Fiji, collected by W. R. Steadman, date of collection unknown.

Bistolida stolida thakau Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 318.
= *Cypraea stolida* Linnaeus, 1758.
Holotype: D14147, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.

Genus *Blasicrura* Iredale, 1930

Blasicrura rhinoceros vivia Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 323.
= *Cypraea pallidula* Gaskoin, 1849.
Holotype: D14157, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Callistocypraea* Schilder, 1927

Callistocypraea aurantium turanga Steadman & Cotton, 1943.
Rec. S. Aust. Mus. 7(4): 329–30.
= *Cypraea aurantium* Gmelin, 1791.
Holotype: D14165, adult specimen, from Nadroga Fiji, collector and date of collection unknown.
Note: Steadman and Cotton (1943) mention a further twelve specimens obtained from Fijian natives at Nadroga, but did not designate any paratypes.

Genus *Cribraria* Jousseaume, 1884

Cribraria cribraria northi Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 318.
= *Cypraea cribraria* Linnaeus, 1758.
Holotype: D14146, adult specimen, from Nadroga, Fiji, collected by W. O. North, date of collection unknown.
Note: Steadman and Cotton (1943) mention a further nineteen specimens from Suva and Nadroga, but did not designate any paratypes.

Cribraria haddnightae Trenberth, 1973
Malac. Soc. S. Aust. Occ. Publ. **17**: no pagination, pls 1,2.
= *Cypraea haddnightae* (Trenberth, 1973).
Holotype: D15132, adult specimen, dead collected, on beach, from Parrys Beach, west of Denmark, near Albany, W. A., collected by F. Haddrill and M. Knight, date of collection unknown.
Note: According to Trenberth (1973), paratypes of this species are in the private collections of Miss F. Haddrill, Miss M. Knight, W. P. Trenberth and R. Summers. The current whereabouts of these specimens are unknown.

Genus *Cypraea* Linnaeus, 1758

Cypraea bregeriana var. ***barbara*** Kenyon, 1902
J. Conch. Lond. **10**(6): 183.
= *nomen inquirendum*.
Holotype: D4210, adult specimen, dead collected, from New Caledonia, collector and date of collection unknown. (Fig. 1A–C).

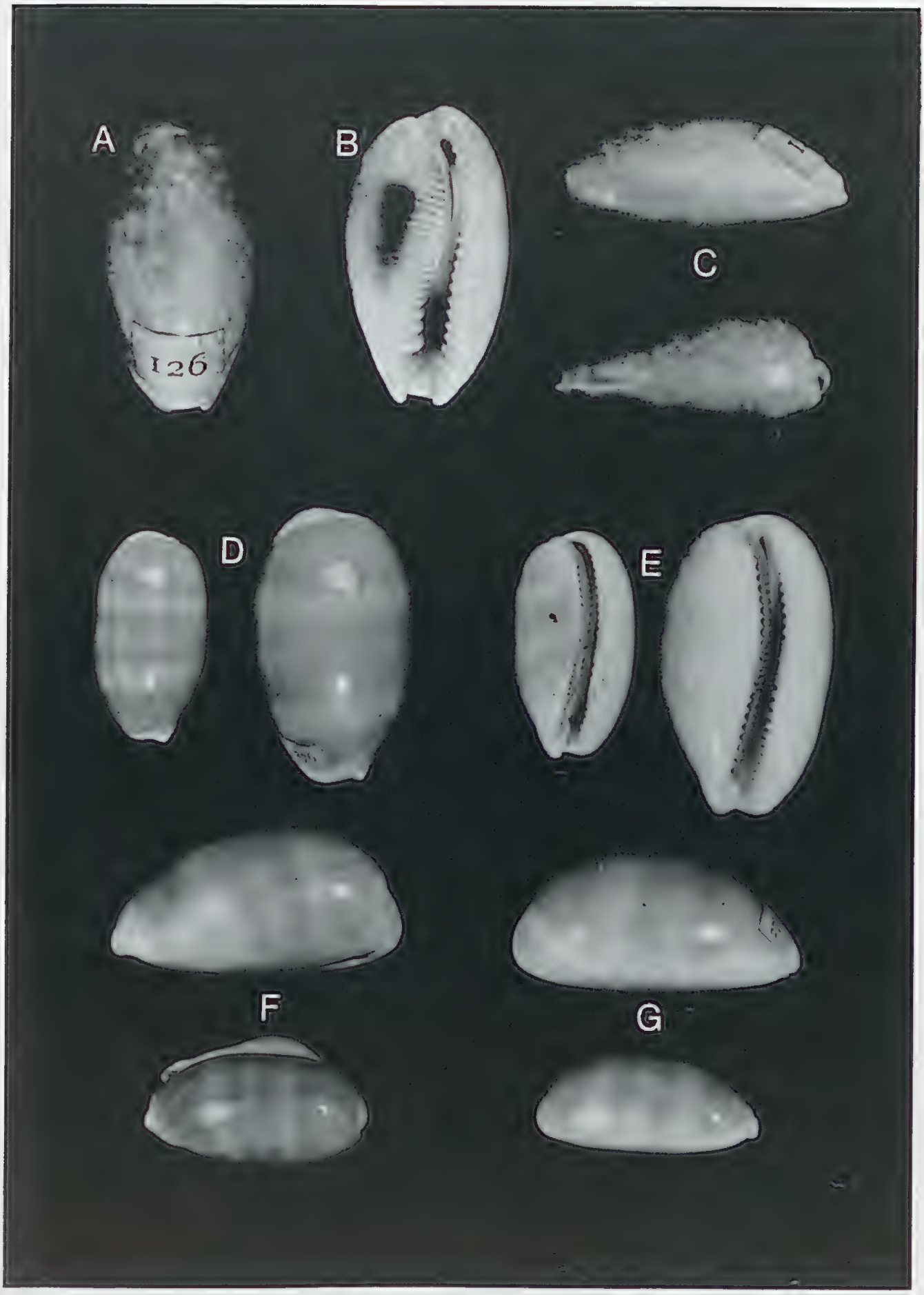

FIGURE 1. A–C: *Cypraea bregeriana* var. *barbara* Kenyon, 1902, holotype, SAM D4210, x 1.8. D–G: *Cypraea carneola* var. *rubiola* Kenyon, 1902, syntypes, SAM D3970, x 0.9.

FIGURE 2. *Cypraea helvola* var. *borneensis* Kenyon, 1902, syntypes, SAM D3578, x 2.5.

FIGURE 3. *Cypraea helvola* var. *timorensis* Kenyon, 1902, syntypes, SAM D3705, x 1.7.

Note: The oldest label with the specimen, in Sir Joseph Verco's handwriting, queries the name of this species, but as the specimen matches Kenyon's (1902) detailed description very closely, we believe it is the holotype. This name was not listed by Burgess (1985), and the holotype is clearly not a specimen of *Cypraea bregeriana* Crosse, 1868, as described by Burgess (1985). The specimen was not live collected, and cannot be identified with certainty as any currently recognised species. We believe, therefore, the most appropriate course is to regard this name as a *nomen inquirendum*.

Cypraea caputserpentis var. ***caputcolubri*** Kenyon, 1898
Proc. Malac. Soc. Lond. 3(2): 79, fig. 3.
= *Cypraea caputserpentis* Linnaeus, 1758.
Syntype: D11561, one adult specimen, dead collected, no collection data.
Note: Kenyon (1898) mentions two specimens, one from the Hawaiian Islands and a 'fine live specimen from Lord Howe Island'. We assume that Kenyon's (1898) description and measurements refer to the live collected specimen, as this was the specimen that prompted her to describe the new variety. Unfortunately, this specimen cannot be located in our collections, and as we have most of the Kenyon Collection, we presume that it is lost. The SAM specimen listed here is smaller than the measurements given by Kenyon (1898), and as it is not live collected, we assume that it came from the Hawaiian Islands.

Cypraea carneola var. ***rubiola*** Kenyon, 1902
J. Conch. Lond. **10**(6): 184.
= *Cypraea carneola* Linnaeus, 1758
Syntypes: D3970, two specimens, one adult and one subadult, from the Hawaiian Islands, collector and date of collection unknown. (Fig. 1D–G).
Note: This name was not listed by Burgess (1985), but these specimens are conspecific with *C. carneola*.

Cypraea helvola var. ***borneensis*** Kenyon, 1902.
J. Conch. Lond. **10**(6): 183–4.
= *Cypraea helvola* Linnaeus, 1758.
Syntypes: D3578, five adult specimens, from Borneo, collector and date of collection unknown. (Fig. 2).
Note: This name was not listed by Burgess (1985), but the types are typical, but small, specimens of *C. helvola*.

Cypraea helvola var. ***timorensis*** Kenyon, 1902
J. Conch. Lond. **10**(6): 184.
= *Cypraea helvola* Linnaeus, 1758.
Syntypes: D3705, seven adult specimens, from Timor, collector and date of collection unknown. (Fig. 3).
Note: This name is not listed by Burgess (1985), but the types are typical specimens of *C. helvola*.

Cypraea irvineanae Cox, 1889
Proc. Linn. Soc. N.S.W. 4: 659, pl. 19, figs 7–9.
= *Cypraea stolida* Linnaeus, 1758.
Holotype: D3772, adult specimen, from Cape Naturaliste, W.A., collector and date of collection unknown.
Note: This specimen lacks the dorsal brown blotch which is usually so typical of *C. stolida*.

Cypraea kaiseri Kenyon, 1897
Proc. Linn. Soc. N.S.W. **22**(1): 145.
= *Cypraea pyriformis* Gray, 1824.
Holotype: D3782, adult specimen, from Lagrange Bay, W.A., collector and date of collection unknown.

Cypraea kauilani Kenyon, 1900
Proc. Malac. Soc. Lond. 4(2): 68, fig. 1.
= *Cypraea erosa* Linnaeus, 1758.
Holotype: D3781, adult specimen, from the Hawaiian Islands, collector and date of collection unknown. (Fig. 4A–C).
Note: This name was not listed by Burgess (1985), but we believe it is a specimen of the rare Hawaiian variety of *C. erosa*.

Cypraea mappa var. ***viridis*** Kenyon, 1902
J. Conch. Lond. **10**(6): 183.
= *Cypraea mappa* Linnaeus, 1758.
Syntypes: D3996, three adult specimens, from New Caledonia, collector and date of collection unknown.

Cypraea miliaris var. ***diversa*** Kenyon, 1902
J. Conch. Lond. **10**(6): 184.
= *Cypraea miliaris* Gmelin, 1791.
Syntypes: D3903, two adult specimens, from Shark Bay, W.A., collector and date of collection unknown.

Cypraea poraria var. ***vibex*** Kenyon, 1902
J. Conch. Lond. **10**(6): 184.
= *Cypraea poraria* Linnaeus, 1758.
Holotype: D18771, adult specimen, from New Caledonia, collector and date of collection unknown. (Fig. 4D–F).
Note: Kenyon (1902) mentions another specimen from the New Hebrides but it does not seem to have been used in her description, nor is it clear if it was before her at the time of description. We therefore assume that the SAM specimen is a holotype. This name was not listed by Burgess (1985), however, we believe it is simply an aberrant specimen of *C. poraria*.

Cypraea tigris amboolee Steadman & Cotton, 1943.
Rec. S. Aust. Mus. 7(4): 332.
=*Cypraea tigris* Linnaeus, 1758.

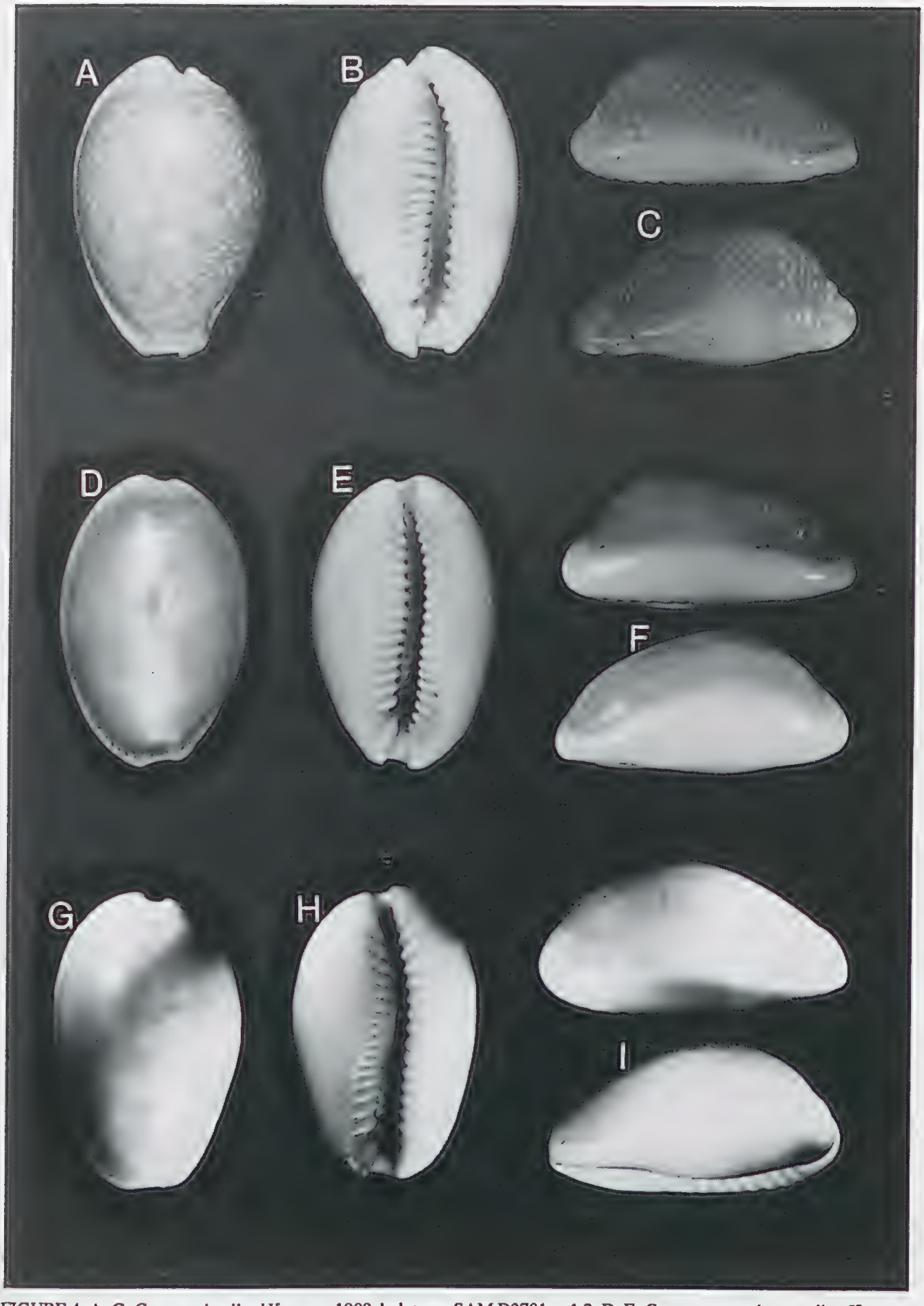

FIGURE 4. A–C: *Cypraea kauilani* Kenyon, 1900, holotype, SAM D3781, x 1.2. D–F: *Cypraea poraria* var. *vibex* Kenyon, 1902, holotype, SAM D18771, x 1.9. G–I: *Cypraea wilhelmina* Kenyon, 1897, holotype, SAM D14447, x 2.5.

Holotype: D14169, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva, Nadroga and Nairai, but did not designate any paratypes.

Cypraea tigris var. *lineata* Kenyon, 1902
J. Conch. Lond. **10**(6): 183.
= *Cypraea tigris* Linnaeus, 1758.
Syntype: D7107, one adult specimen, from Fiji, collector and date of collection unknown.
Note: Kenyon (1902) mentions several other specimens but these cannot be located in our collections with any confidence.

Cypraea tigris volai Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 332
= *Cypraea tigris* Linnaeus, 1758.
Holotype: D14168, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Cypraea (Notocypraea) trenberthae Trenberth, 1961
R. Soc. S. Aust. Malac. Sect. Occ. Publ. **15**: no pagination, fig.
= *Cypraea comptonii* Gray, 1847.
Holotype: D14616, live collected adult specimen, from Tumby Bay, Eyre Peninsula, S.A., collector and date of collection unknown.
Note: According to Trenberth (1961) there are four paratypes, two in his own collection, one in the collection of R. Summers, and one with the Malacological Society of Australia, Melbourne. The latter is in the Museum of Victoria (F31257), but the whereabouts of the other specimens is unknown.

Cypraea wilhelmina Kenyon, 1897
Proc. Linn. Soc. N.S.W. **22**(1): 145.
= *nomen inquirendum.*
Holotype: D14447, worn adult specimen, dead collected, from W.A., collector and date of collection unknown. (Fig. 4G–I).
Note: Kenyon (1897) also mentions one young specimen and three others from the same locality 'similar in shape and dentition to *C. poraria*' which she considers may be varieties of *C. wilhelmina*. We have been unable to locate these specimens in our collections. This name was not listed by Burgess (1985). This specimen may be an example of *C. poraria* Linnaeus, 1758, but differs on some points.

Genus *Erosaria* Troschel, 1863

Erosaria (Erosaria) helenae nasese Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 315.
= *Cypraea labrolineata* Gaskoin, 1849.
Holotype: D14142, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another two specimens from Suva, but did not designate any paratypes.

Genus *Erronea* Troschel, 1863

Erronea errones bartletti Steadman & Cotton, 1946
Rec. S. Aust. Mus. 8(3): 508.
= *Cypraea ovum* Gmelin, 1791.
Holotype: D15944, adult specimen, from Rossell Island, Papua New Guinea, collected by H. K. Bartlett, date of collection unknown.
Note: Steadman and Cotton (1946) mention two other specimens but did not designate paratypes. This name was not listed by Burgess (1985), but the holotype is obviously a specimen of *C. ovum*, not *C. errones* Linnaeus, 1758.

Erronea nimisserans kalavo Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 324.
= *Cypraea errones* Linnaeus, 1758.
Holotype: D14159, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Erronea nimisserans vivili Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 324.
= *Cypraea errones* Linnaeus, 1758.
Holotype: D14160, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.

Genus *Evenaria* Iredale, 1930

Evanaria(sic) asellus kawakawa Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 320.
= *Cypraea asellus* Linnaeus, 1758.

Holotype: D14151, adult specimen, dead collected, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention a further eleven specimens from Suva and Nadroga, but did not designate any paratypes.

Evanaria(sic) hirundo korolevu Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 320-1.
= *Cypraea hirundo* Linnaeus, 1758.
Holotype: D14152, adult specimen, from Korolevu, Viti Levu, Fiji, collected by W. R. Steadman, date of collection unknown. (Fig. 5A–C).
Note: Steadman and Cotton (1943) mention another thirty specimens from Suva and Nadroga, but did not designate any paratypes. Although Burgess (1985) synonymises this name with *C. hirundo*, the holotype appears to show more resemblance to *C. ursellus* Gmelin, 1791.

Evanaria(sic) ursellus vitiensis Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 321.
= *Cypraea kieneri* Hidalgo, 1906.
Holotype: D14153, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another nineteen specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Guttacypraea* Iredale, 1935

Guttacypraea euclia Steadman & Cotton, 1946
Rec. S. Aust. Mus. 8(3): 506.
= *Cypraea pulicaria* Reeve, 1846.
Holotype: D11634, adult specimen with dried remains of animal, dredged live in 183m (100fm), Great Australian Bight, 90 miles west of Eucla, W.A., F.R.V. 'Endeavour', collected by J. C. Verco, Mar 1912.
Note: Steadman and Cotton (1946) mention other specimens but did not designate any paratypes.

Genus *Leporicypraea* Iredale, 1930

Leporicypraea mappa rewa Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 329.
= *Cypraea mappa* Linnaeus, 1758.
Holotype: D14164, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another thirty nine specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Lyncina* Troschel, 1863

Lyncina lynx pacifica Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 330.
= *Cypraea lynx* Linnaeus, 1758.
Holotype: D14166, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Melicerona* Iredale, 1930

Melicerona melvilli vatu Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 322–3.
= *Cypraea felina* Gmelin, 1791.
Holotype: D14156, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention a further twenty nine specimens from Suva and Nadroga, but did not designate any paratypes. This name was not listed by Burgess (1985), but the holotype is a specimen of *C. felina*.

Genus *Monetaria* Troschel, 1863

Monetaria (Monetaria) moneta endua Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 317.
= *Cypraea moneta* Linnaeus, 1758.
Holotype: D14143, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Monetaria (Monetaria) moneta erua Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 317.
= *Cypraea moneta* Linnaeus, 1758.
Holotype: D14144, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

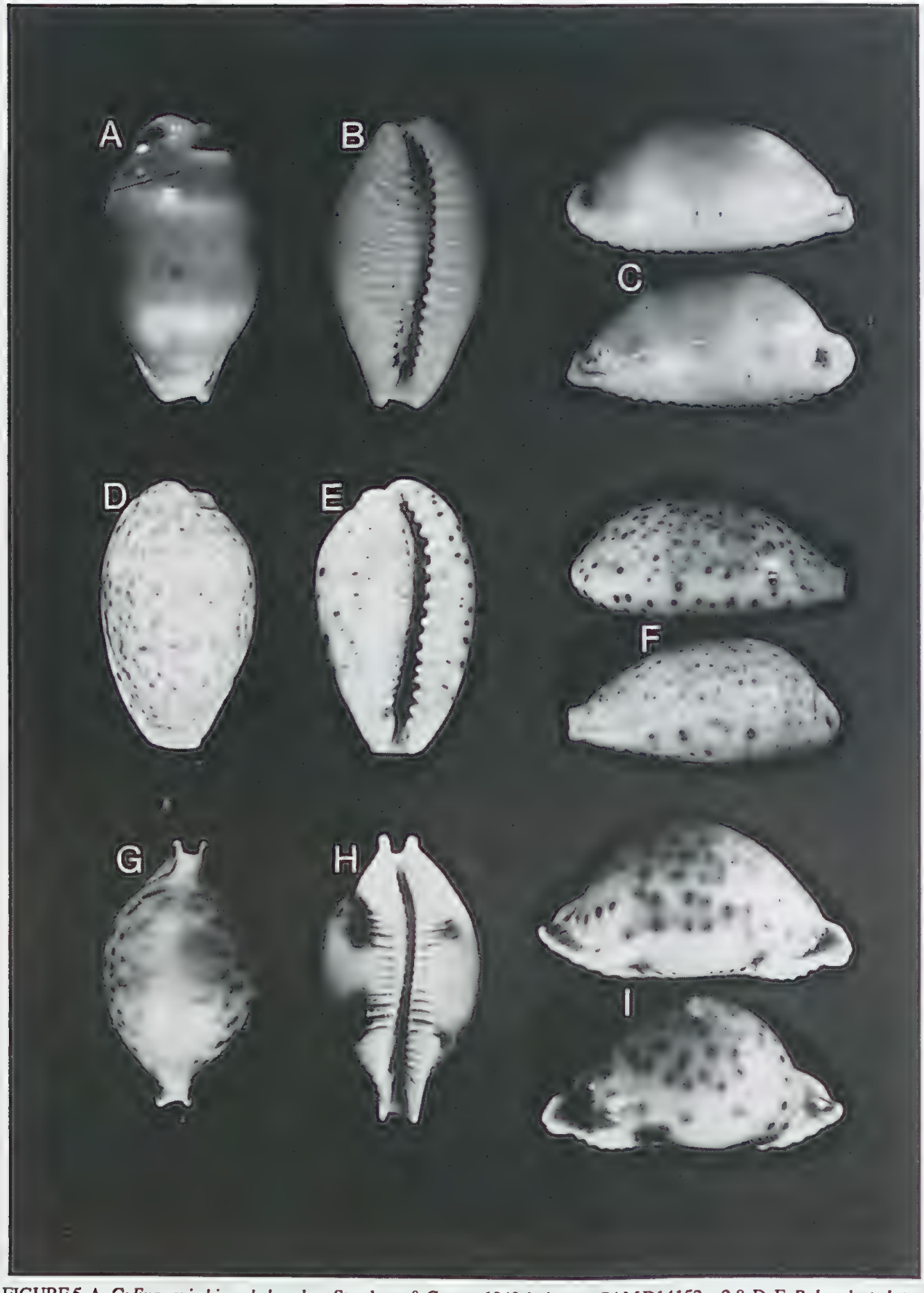

FIGURE 5. A–C: *Evanaria hirundo korolevu* Steadman & Cotton, 1943, holotype, SAM D14152, x 2.8. D–F: *Palmadusta lutea yaloka* Steadman & Cotton, 1943, holotype, SAM D14154, x 2.1. G–I: *Pustularia (Pustularia) cicerula jennisoni* Steadman & Cotton, 1943, holotype, SAM D14138, x 2.4.

Monetaria (Monetaria) moneta etolu Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 317.
= *Cypraea moneta* Linnaeus, 1758.
Holotype: D14145, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Notocypraea* Schilder, 1927

Notocypraea verconis Cotton & Godfrey, 1932
S. Aust. Nat. 13:41, pl. 1, fig. 8.
= *Cypraea angustata* Gmelin, 1791.
Holotype: D13475, worn, damaged adult specimen, dead collected, from Gulf St Vincent, S.A., collector and date of collection unknown.
Note: Cotton and Godfrey (1932) list the registration number of the holotype as D10173. They also mention a number of other specimens but did not designate paratypes.

Genus *Palangerosa* Iredale, 1931

Palangerosa cylindrica wangga Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 323–4.
= *Cypraea cylindrica* Born, 1778.
Holotype: D14158; adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention a further two specimens from Suva, but did not designate any paratypes.

Genus *Palmadusta* Iredale, 1930

Palmadusta lutea yaloka Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 322.
= *Cypraea yaloka* (Steadman & Cotton, 1943).
Holotype: D14154, adult specimen, from Nadroga, Fiji, collected by W. O. North, date of collection unknown. (Fig. 5D–F).
Note: Steadman and Cotton (1943) mention another specimen collected from the type locality by Steadman, but did not designate it as a paratype. Burgess (1985:141) regards this as a valid species, but confuses the issue by stating 'I examined Gray's type of *C. humphreysii* in the British Museum in 1968. It was identical with *C. yaloka* Steadman & Cotton', and further stating 'Since the original descriptions and illustrations of *C. humphreysii* and *C. nivea* clearly refer to *C. lutea* these names must be regarded as synonyms'. According to Burgess (1985) the specific conchological character separating *C. yaloka* from *C. lutea* Gmelin, 1791, is the number of white transverse bands on the dorsum, with *C. lutea* having two bands and *C. yaloka* three bands. Whether or not both species can be maintained cannot be resolved here, and would require the examination of a large series of specimens including the animal. However, if the three-banded form is a valid species and also matches the type of *C. humphreysii* Gray, 1825, then the correct name for this species is *C. humphreysii* not *C. yaloka* (Article 23, ICZN).

Genus *Paulonaria* Iredale, 1930

Paulonaria minoridens suvaensis Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 319–20.
= *Cypraea minoridens* Melvill, 1901.
Holotype: D14150, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another seven specimens from the type locality, but did not designate any paratypes.

Genus *Ponda* Jousseaume, 1884

Ponda ventriculus topee Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 331.
= *Cypraea ventriculus* Lamarck, 1810a.
Holotype: D14167, adult specimen, from Kaduva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another two specimens from the type locality, but did not designate any paratypes.

Genus *Pustularia* Swainson, 1840

Pustularia (Pustularia) cicercula jennisoni Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 310–1.
= *Cypraea bistrinotata* Schilder & Schilder, 1937.
Holotype: D14138, adult specimen, from Taveuni, Fiji, collected by R. C. Jennison, date of collection unknown. (Fig. 5G–I).
Note: Steadman and Cotton (1943) mention another eleven specimens from Suva, Taveuni and Naseli, but did not designate any paratypes. This name was not listed by Burgess (1985), but we believe it is probably a specimen of *C. bistrinotata*, not *C. cicercula* Linnaeus, 1758.

Pustularia (Annepona) margarita theeva
Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 310.
= *Cypraea dillwyni* Schilder, 1922.
Holotype: D14137, adult specimen, from Nadroga, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another five specimens from Nadroga, but did not designate any paratypes.

Pustularia (Pustularia) tricornis vulavula
Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 311.
= *Cypraea cicercula* Linnaeus, 1758.
Holotype: D14139, adult specimen, from Nadroga, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another nine specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Solvadusta* Iredale, 1935

Solvadusta subviridis kesata Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 322.
= *Cypraea subviridis* Reeve, 1835.
Holotype: D14155, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.

Genus *Staphylea* Jousseaume, 1884

Staphylea (Staphylea) nukulau Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 312.
= *Cypraea staphylaea* Linnaeus, 1758.
Holotype: D14140, adult specimen, from Nukulau, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another twenty specimens from Suva and Nadroga, but did not designate any paratypes.

Staphylea (Purperosa)(sic) purperosa ruvaya
Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 312–3.
= *Cypraea limacina* Lamarck, 1810b.
Holotype: D14141, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another three specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Talostolida* Iredale, 1930

Talostolida subteres vava Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 319.
= *Cypraea teres* Gmelin, 1791.
Holotype: D14149, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown. (Fig. 6A–C).
Note: Steadman and Cotton (1943) mention another nine specimens from Suva and Nadroga, but did not designate any paratypes. This name was not listed by Burgess (1985), but we believe it is a specimen of *C. teres* rather than *C. subteres* Weinkauff, 1881.

Genus *Zoila* Jousseaume, 1884

Zoila episema Iredale, 1939
Aust. Zool. 9(3): 300–1, pl. 27, figs 3, 4.
= *Cypraea venusta* Sowerby, 1846.
Holotype: D3980, adult specimen, from Cape Naturaliste, W.A., collector and date of collection unknown. (Fig. 6D–F).
Note: This specimen was originally purchased by Mrs A. Kenyon for £20 from Mrs Irving as the 'type' of *Cypraea thatcheri* Cox, 1869, and later acquired by Sir Joseph Verco and donated to SAM. Verco, however, recognised it was not the type of Cox's species, which was sent by Cox to the Natural History Museum, London. Type unique.

Zoila friendii vercoi Schilder, 1930
Zool. Anz. 92(1/2): 74–5.
= *Cypraea friendii* Gray, 1831.
Holotype: D14124(ex D969), adult specimen, from Esperance, W.A., collected by J. C. Verco, date of collection unknown. (Fig. 6G–I).

Zoila rosselli Cotton, 1948
Trans. R. Soc. S. Aust. 72(1): 30–31, pl. 1, figs 1–6.
= *Cypraea rosselli* (Cotton, 1948).
Holotype: D14220, adult specimen, dorsum eroded with acid, from a beach near North Wharf, Fremantle, W.A., collected by H. Rossell, date of collection unknown.
Note: Cotton (1948) mentions another five specimens, but did not designate any paratypes.

Family OVULIDAE

Genus *Crenavolva* Cate, 1973

Crenavolva cruenta Gowlett-Holmes & Holmes, 1989
Trans. R. Soc. S. Aust. 113(4): 208–13, figs 2, 3(fig. only), 7(caption only).

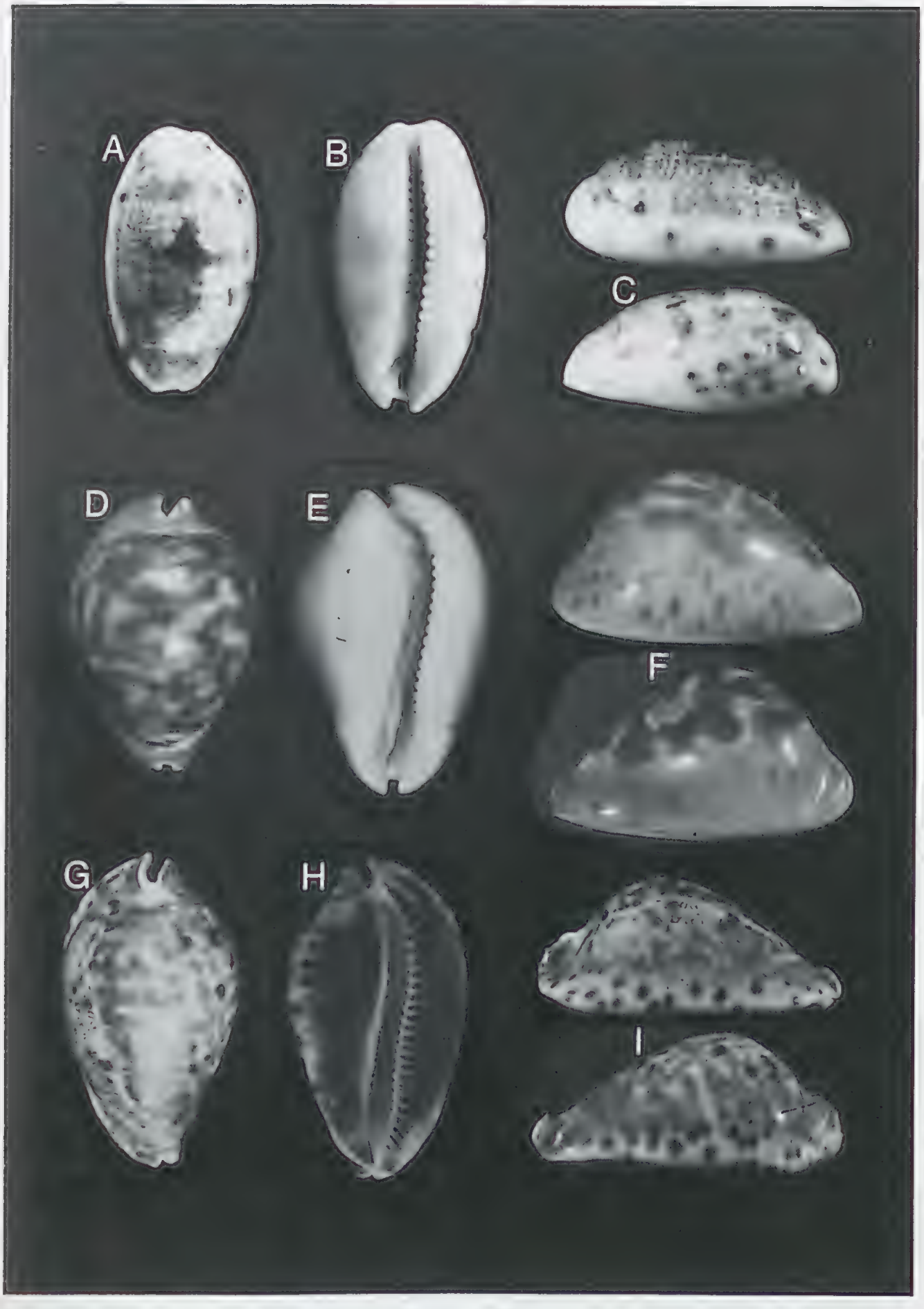

FIGURE 6. A–C: *Talostolida subteres vava* Steadman & Cotton, 1943, holotype, SAM D14149, x 1.7. D–F: *Zoila episema* Iredale, 1939, holotype, SAM D3980, x 0.6. G–I: *Zoila friendii vercoi* Schilder, 1930, holotype, SAM D14124, x 0.5.

Holotype: D18431, adult specimen with dried animal, from on gorgonian coral (*Echinogorgia* sp.), in 15 m, from 1.6 km east of Point Douglas, northern Spencer Gulf, S.A., collected by N. J. C. Holmes, 5 May 1988.
Paratypes: D18432, 31 specimens (6 immature), all with dried animals, with same collection data as holotype. D18433, 38 specimens (14 immature) with animals, in spirit, with same collection data as holotype. D18437, 11 adult specimens, all with dried animals, with same collection data as holotype.
Note: Two paratypes from D18432 are now in the collections of the Academy of Natural Sciences, Philadelphia. In the original description of this species (Gowlett-Holmes & Holmes, 1989), figs 3 and 7 were transposed, although the captions are correct.

Genus *Primovula* Thiele, 1925

Primovula (Primovula) heleneae Cate, 1973
Veliger Suppl. **15**: 43, fig. 89.
Holotype: D15943, 1 worn, damaged, adult specimen, dredged dead in Gulf St Vincent or Spencer Gulf, S.A., collected by J. C. Verco, date of collection unknown.
Note: This specimen is also a paratype of *Prosimnia verconis* Cotton & Godfrey, 1932, also listed here, but Cate (1973) recognised it as a different species.

Genus *Prosimnia* Schilder, 1927

Prosimnia verconis Cotton & Godfrey, 1932
S. Aust. Nat. **13**: 46, pl. 1, fig. 15.
= *Crenavolva verconis* (Cotton & Godfrey, 1932).
Holotype: D13476, worn, adult specimen, dredged dead in 65 m (35 fm), off St Francis Island, Nuyts Archipelago, S.A., collected by J. C. Verco, date of collection unknown.
Paratype: D15943, one worn, damaged, adult specimen, dredged dead in Gulf St Vincent or Spencer Gulf, S.A., collected by J. C. Verco, date of collection unknown.
Note: There were originally 3 specimens (see Gowlett-Holmes & Holmes, 1989). The above paratype (D15943) does not represent this species and was selected by Cate (1973) as the holotype of *Primovula (Primovula) heleneae* Cate, 1973, also listed here.

Family TRIVIIDAE

Subfamily TRIVIINAE

Genus *Cleotrivia* Iredale, 1930

Cleotrivia bathypilula Iredale, 1935
Aust. Zool. 8(2): 100.
= *Niveria (Cleotrivia) pilula bathypilula* (Iredale, 1935).
Syntypes: D876, three specimens, dredged in 22–25 m (12–14 fm), King George Sound, W.A., collected by J. C. Verco, date of collection unknown. D909, one adult specimen, dredged in 148 m (81 fm), Great Australian Bight, 80 miles west of Eucla, W.A., F.R.V. 'Endeavour', collected by J. C. Verco, Mar 1912. D910, one specimen, dredged in 132 m (72 fm), Great Australian Bight, 40 miles west of Eucla, W.A., F.R.V. 'Endeavour', collected by J. C. Verco, Mar. 1912.
Note: D909 and D910 are the holotype and paratype respectively of *Niveria (Cleotrivia) pilula euclaensis* Cate, 1979, also listed here, an unnecessary replacement name.

Genus *Niveria* Jousseaume, 1884

Niveria (Cleotrivia) corallina Cate, 1979
San Diego Soc. Nat. Hist. Mem. **10**: 56, fig. 70.
Holotype: D16221, adult specimen, ex Kenyon Collection, locality and date of collection unknown.
Note: Cate (1979) states that the type locality of this species is 'unknown: thought to be from South Australia'. As this specimen is from the Kenyon Collection, it is most unlikely to be from South Australia, and the type locality should be regarded as unknown. The registration number cited by Cate (1979) for this species (D4095C) is an old number for D16221.

Niveria (Cleotrivia) dorsennus Cate, 1979
San Diego Soc. Nat. Hist. Mem. **10**: 56, fig. 69.
Holotype: D16222, adult specimen, ex Kenyon Collection, locality and date of collection unknown.
Note: Cate (1979) states that the type locality of this species is 'unknown: thought to be from South Australia'. As this specimen is from the Kenyon Collection, it is most unlikely to be from South Australia, and the type locality should be regarded as unknown. The registration number cited by Cate (1979) for this species (D4095B) is an old number for D16222.

Niveria (Cleotrivia) meridionalis Cate, 1979
San Diego Soc. Nat. Hist. Mem. **10**: 54, fig. 68.
Holotype: D16223, adult specimen, ex Kenyon Collection, locality and date of collection unknown.
Note: Cate (1979) states that the type locality of this species is 'not known: thought to be from the south Australian coast'. As this specimen is from the Kenyon Collection, it is most unlikely to be from South Australia, and the type locality should be regarded as unknown. The registration number cited by Cate (1979) for this species (D4095A) is an old number for D16223.

FIGURE 7. *Erato bimaculata* Tate, 1878, syntypes, SAM D913, x 8.

Niveria (Cleotrivia) pilula euclaensis Cate, 1979
San Diego Soc. Nat. Hist. Mem. **10**: 59, fig. 73.
= *Niveria (Cleotrivia) pilula bathypilula* (Iredale, 1935).
Holotype: D909, adult specimen, dredged in 148 m (81 fm), Great Australian Bight, 80 miles west of Eucla, W.A., F.R.V. 'Endeavour', collected by J. C. Verco, Mar 1912.
Paratype: D910, one specimen, dredged in 132 m (72 fm), Great Australian Bight, 40 miles west of Eucla, W.A., F.R.V. 'Endeavour', collected by J. C. Verco, Mar 1912.
Note: Cate (1979) erected this replacement name for *Cleotrivia bathypilula* Iredale, 1935, believing the latter to be invalid. However, Iredale's (1935) name was validly erected.

Genus *Trivia* Broderip, 1837

Trivia acutisulcata Kenyon, 1900
Proc. Malac. Soc. Lond. 4(2): 69, fig. 2.
= *Niveria (Cleotrivia) globosa* (Sowerby, 1832).
Holotype: D4085, adult specimen, ex Kenyon Collection, locality and date of collection unknown.

Genus *Trivirostra* Jousseaume, 1884

Trivirostra cydarum Cate, 1979
San Diego Soc. Nat. Hist. Mem. **10**: 95, fig. 151.
Holotype: D16224, adult specimen, ex Kenyon Collection, locality and date of collection unknown.
Note: Cate (1979) states that the type locality of this species is 'unknown....thought to have been from the Gulf St Vincent area of South Australia (34°55'S, 138°10'E)'. As this specimen is from the Kenyon Collection, it is most unlikely to be from South Australia, and the type locality should be regarded as unknown. The registration number cited by Cate (1979) for this species (D4095) is an old number for D16224.

Subfamily ERATOINAE

Genus *Erato* Risso, 1826

Erato bimaculata Tate, 1878
Trans. Proc. Rep. Phil. Soc. Adel. **1**: 88.
Syntypes: D913, six specimens, dead collected, in beach sand, from Aldinga and Marino, near Adelaide, S.A., collected by R. Tate, date of collection unknown. (Fig. 7).
Note: One of the above specimens is labelled 'type example', but this was probably added later by B. C. Cotton. Tate (1878) also mentions another four specimens, but the current whereabouts of these is unknown.

Acknowledgments

We would like to thank Mr I. Loch, Australian Museum, and Dr F. E. Wells, Western Australian Museum, for constructive comments on the manuscript. The photographs were taken by Mrs J. Forrest and Mr R. Hamilton-Bruce.

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JEFFOCORIS GEN. N. – A NEW PODOPINE GENUS FROM AUSTRALIA (HETEROPTERA: PENTATOMIDAE)

J. DAVIDOVÁ-VILÍMOVÁ

DAVIDOVÁ-VILÍMOVÁ, J. 1993. *Jeffocoris* gen. n. – a new podopine genus from Australia (Heteroptera: Pentatomidae). *Rec. S. Aust. Mus.* 26(2):105–109.

The new genus *Jeffocoris* and new species *J. grossi* of the subfamily Podopinae are described from Australia, where nine podopine genera are now known. *Jeffocoris* is compared with the related genus *Deroploopsis*.

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Schouteden (1906), in the first revision of genera of the subfamily Podopinae (as Graphosomatinae), listed five genera from the tribe Graphosomatini (as Graphosomataria) as occurring in Australia: *Deroploa* Westwood, 1835; *Testrica* Walker, 1867, with the new subgenus *Protestrica; Testricoides Schouteden*, 1905 (a junior synonym of *Dandinus* Distant, 1904); *Numilia* Stål, 1867 and *Deroploopsis*. The last genus was originally described by Schouteden (op. cit.), with the type species *Deroploa curvicornis* Stål, 1876. Stål (1876), in one of the first papers on Australian Pentatomoidea, mentioned only three podopine genera: *Testrica, Numilia* and *Deroploa*.

Musgrave (1930) published the next revision of Australian representatives of the subfamily Podopinae (as Graphosomatinae). He listed eight genera from the tribe Graphosomatini: *Deroploopsis* Schouteden, 1906; *Deroploa*; *Eufroggattia* Goding, 1903; *Numilia; Dandinus; Testrica; Protestrica;* and *Propetestrica;* the last was described (op. cit.) as a new genus.

Gross (1975), in the last comprehensive study of Australian Pentatomoidea, classified the representatives of the Podopinae in two genus groups: genus group *Podops* Laporte, 1832 (approximately the tribe Podopini) and genus group *Tarisa* Amyot and Serville, 1843 (approximately the tribe Graphosomatini). Gross mentioned five podopine genera from the genus group *Tarisa* occurring in South Australia: *Deroploopsis, Dandinus, Testrica, Protestrica* and *Propetestrica*.

A new podopine genus from Western Australia was recognised during a complex revision of all genera of the subfamily Podopinae. Nine podopine genera are now known from Australia: *Dandinus, Deroploa, Deroploopsis, Eufroggattia, Numilia, Propetestrica, Protestrica, Testrica,* and the new genus, *Jeffocoris*.

Methods

The terminology of male external genitalia follows Davidová-Vilímová & McPherson (1992).

The pygophore in this paper is illustrated upside down with the dorsal rim down, ventral rim up. This allows comparison of these illustrations with some recent ones of pentatomoid (Schaefer, 1977; Davidová-Vilímová & McPherson, 1992) or podopine (Schaefer, 1981) pygophores.

Strongly sclerotised and pigmented parts are represented by stippling on the illustrations.

Jeffocoris gen. n.

Type species: *Jeffocoris grossi* sp. n. (by monotypy).

Etymology

The name of the genus is derived from the personal name of Jeff Parris. The gender is masculine.

Diagnosis

Ground colour dark brown with pale brown to beige spots on head and pronotum, and longitudinal keels on pronotum and scutellum.

Head slightly slanted ventrally; with almost rectangular outline, apex broadly rounded (Fig. 1). Approximately anterior 1/3 of length of head recurved dorsally at right angle.

Pronotum with long, robust process with wide, undivided apex at lateral angle. One medial longitudinal keel and two sublateral oblique keels (Fig. 2).

Orifice of metapleural scent gland on top of protuberance bent in several places; protuberance placed halfway along width of metapleura and at 1/4 of length from posterior margin of metapleura. Auricle at orifice absent, evaporative area represented by fine-grained surface of protuberance and of small plate around its base.

Scutellum conspicuously long, exceeding apex of abdomen, narrow; about 1/2 of corium and large part of clavus left uncovered by scutellum (Fig. 4). Proepisternum with flattened anterior margin (Fig. 3).

Abdominal sterna 3–7 with two short trichobothria laterally on each side, trichobothria in transverse position to each other, lateral trichobothrium at spiracular line, shorter than medial one.

Male external genitalia: Paramere conspicuously small, peduncle gradually widens to hypophysis, which narrows to its apex (Figs 8–11). Large, flat infolding of lateral rim of pygophore the most conspicuous structure on pygophore (Figs 5,6), at right angle to lateral wall. Phallus with long, cylindrical phallotheca; conjunctiva with unpaired membranous process divided into two long apices crossing one another (Figs 12–14). Endophallic duct forms short, wide, sclerotised vesica; secondary gonopore slightly recurved ventrally (Figs 12–14).

Diagnosis

Jeffocoris is similar and probably closely related to *Deroploopsis*. The latter genus has five species, three of which were studied during revision of the Podopinae: *D. curvicornis* (Stål, 1876), *D. recticornis* Musgrave, 1930 and *D. trispinosus* Musgrave, 1930.

These two genera share several apomorphic characters within the Podopinae: lateral angle of pronotum with long, robust process; anterior margin of proepisternum flattened; medial longitudinal keel on pronotum developed along the entire length of pronotum; scutellum conspicuously long, exceeding apex of abdomen; evaporative area small, only on metapleura, auricle absent.

Jeffocoris differs from *Deroploopsis* by the following characters.

Head: Sexual dimorphism in shape of head exists in *Deroploopsis*: Head of male is elongate, long mandibular plates do not touch one another before anteclypeus, their apical parts are recurved dorsally at obtuse angle, not at right angle; head of female is of approximately rectangular outline. Only males of *Jeffocoris* are known. Outline of head of male is almost rectangular, mandibular plates touch one another before anteclypeus, about apical 1/3 of length of head is recurved dorsally at right angle (Fig. 1).

Pronotum: Larger, triangular process is developed at anterior angle of pronotum in *Deroploopsis*. Conspicuously long, apically divided process present at lateral angle of pronotum in *Deroploopsis*. Only small process is developed at anterior angle, and process at lateral angle is not divided in *Jeffocoris* (Fig. 2). Pronotum of *Deroploopsis* bears medial longitudinal keel, and laterally one anterior tubercle. Pronotum of *Jeffocoris* bears medial longitudinal keel, and short, sublateral oblique keels on anterior part (Fig. 2).

Orifice of scent gland is at centre of protuberance in *Deroploopsis*, posteromedial in *Jeffocoris*.

Entire scutellum of *Deroploopsis* is brown and only slightly exceeds apex of abdomen. Scutellum of *Jeffocoris* is brown and bears a medial longitudinal beige keel; it conspicuously exceeds apex of abdomen.

Shape of paramere of *Deroploopsis* is very similar to that of *Jeffocoris* (see description) but bears a small membrane connected to peduncle. Paramere of *Jeffocoris* lacks a membrane.

Wide infolding of ventral rim of pygophore is developed in *Deroploopsis*; only narrow infolding is developed in *Jeffocoris*.

Vesica is short, entirely recurved distally in *Deroploopsis*; only slightly recurved posteroventrally in *Jeffocoris*. Medial penial lobe is of more complicated shape in *Deroploopsis* than in *Jeffocoris*.

Jeffocoris grossi sp. n.

Etymology

The name of the species is derived from that of the hemipterist G. F. Gross.

Material examined

Only the type material is known. Holotype: male, West Australia, Dedari, 40 mi W of Coolgardie, 11–21 January 1963, R. E. Turner. Paratype: male, from the same locality. Both type specimens are deposited in the collection of the Natural History Museum, London.

Distribution

Western Australia.

Description

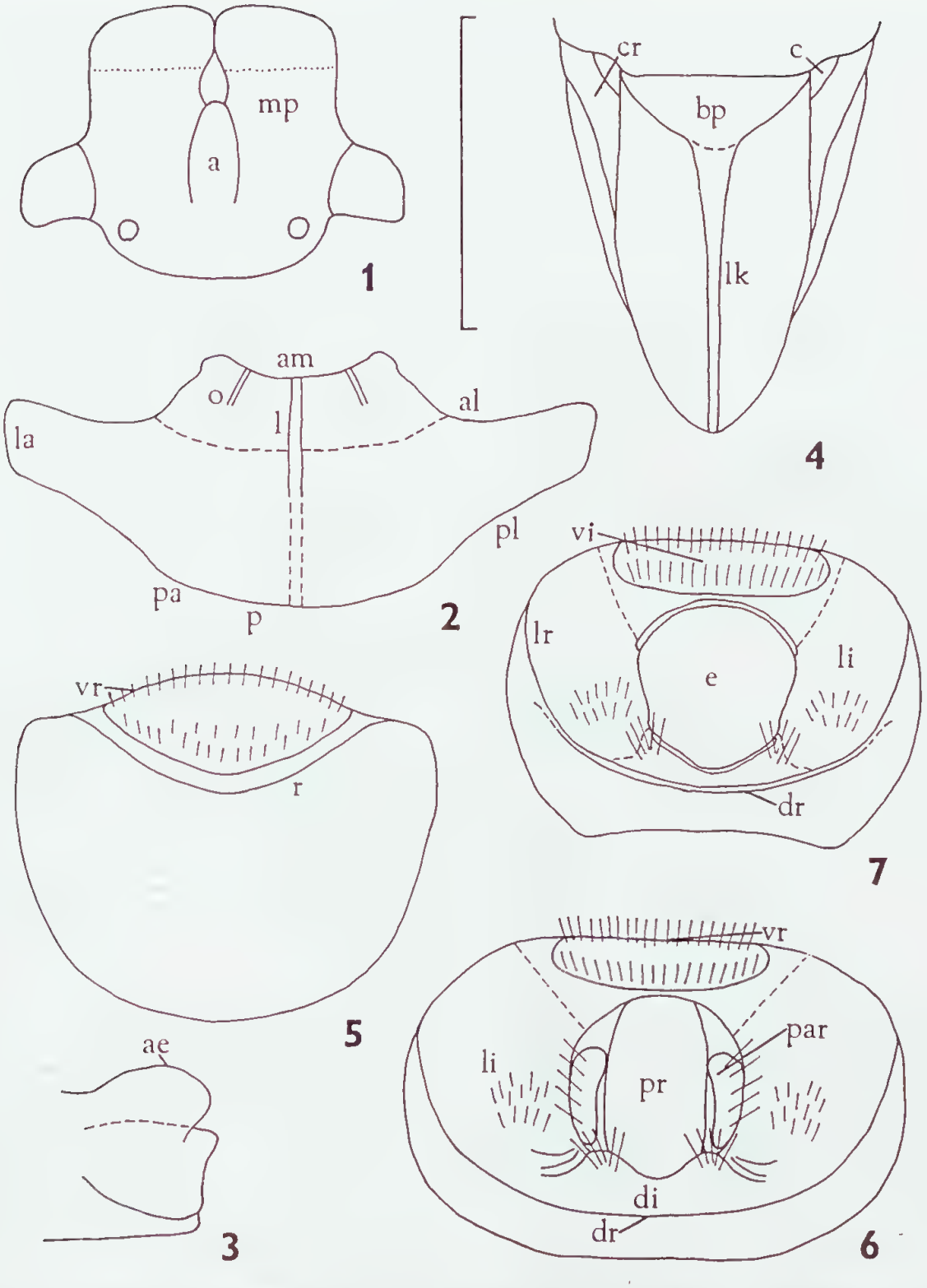
Measurements (in mm, N = 2): Total body length: 4.5 – 4.7; head length: 0.7 – 0.8, width: 1.1 – 1.2; pronotum length: 1.3 – 1.5, width: 4.1 – 4.7.

Head (Fig. 1): Eyes large, a little protuberant (Fig. 1). Mandibular plates about 1/3 longer than anteclypeus, touching one another before anteclypeus. Anterior 1/3 of length of head recurved dorsally at right angle. Anteclypeus narrow, short (Fig. 1). Dorsal surface of head almost flat. Antennae five-segmented, segment 5 longest, segment 1 shortest.

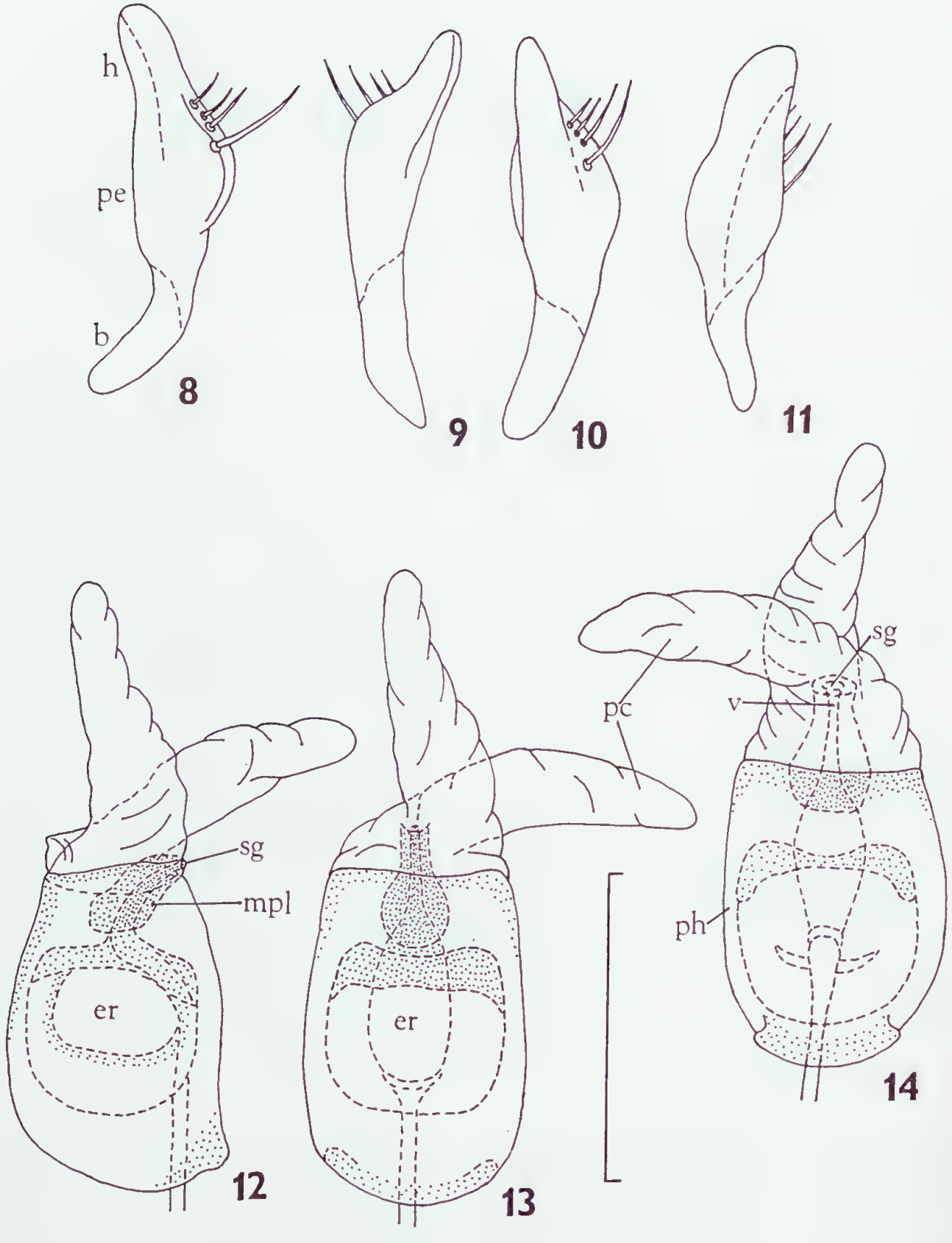
Bucculae short, conspicuously high, with straight ventral margin; dark brown, with yellow stripe on ventral margin. Apex of labium reaching to mesocoxae, segment 1 shorter than bucculae.

Pronotum (Fig. 2): Anterior margin concave; anterior angle with small triangular tooth-shaped process, slanted to beginning of conspicuously concave anterolateral margin. Lateral angle with long, robust process. Posterolateral and posterior margins almost straight, posterior angle rounded.

Median longitudinal, conspicuously elevated keel on anterior 1/3 of pronotum, only slightly elevated on posterior 2/3 of pronotum. Short, oblique keel sublaterally on each side at anterior margin. Transverse keel vaguely outlined on anterior part of pronotum.



FIGURES 1–7. *Jeffocoris grossi*. **1**, head, dorsal view, dotted line = apical part of head recurved dorsally; **2**, pronotum, dorsal view, transverse dashed line = transverse keel, longitudinal dashed line = posterior part of longitudinal keel; **3**, left proepisternum, ventral view; **4**, scutellum, dorsal view, dashed line = posterior outline of basal plate; **5**, pygophore, posterior view; **6**, pygophore, dorsal view, dashed line = contact of infoldings of lateral rim and of ventral rim; **7**, dissected pygophore, dorsal view. **a**, anteclypeus; **ae**, anterior margin of proepisternum; **al**, anterolateral margin of pronotum; **am**, anterior margin of pronotum; **bp**, basal plate of scutellum; **c**, clavus; **cr**, corium; **di**, infolding of dorsal rim of pygophore; **dr**, dorsal rim of pygophore; **e**, external opening of pygophore; **l**, longitudinal keel on pronotum; **la**, lateral angle of pronotum; **li**, infolding of lateral rim of pygophore; **lk**, longitudinal keel on scutellum; **lr**, lateral rim of pygophore; **mp**, mandibular plate; **o**, oblique keel on pronotum; **p**, posterior margin of pronotum; **pa**, posterior angle of pronotum; **par**, paramere; **pl**, posterolateral margin of pronotum; **pr**, proctiger; **r**, ridge on ventral wall of pygophore; **vi**, infolding of ventral rim of pygophore; **vr**, ventral rim of pygophore. Scale line: 0.9 mm: fig. 1; 1 mm: figs. 5–7; 1.1 mm: fig. 3; 1.8 mm: fig. 2; 2.4 mm: fig. 4.



FIGURES 8–14. *Jeffocoris grossi*. 8–11, left paramere, 8, lateral view, 9, medial view, 10, posterior view, 11, anterior view; 12–14, phallus, 12, lateral view, 13, dorsal view, 14, ventral view. b, base of paramere; er, ejaculatory reservoir; h, hypophysis of paramere; mpl, medial penial lobe; pc, process of conjunctiva; pe, peduncle of paramere; ph, phallotheca; sg, secondary gonopore; v, vesica. Scale line: 0.3 mm: figs. 12–14; 0.6 mm: figs. 8–11.

Venter of thorax: Sternal sulcus conspicuously concave, with fine, short pubescence. Anterior margin of proepisternum elongated and flattened (Fig. 3); margins of meso- and metaepisternum rounded. Protuberance with orifice of scent gland narrow at base, widened to apex.

Scutellum and uncovered parts of dorsum of abdomen (Fig. 4): Width of base of scutellum the same as distance between posterior angles of pronotum.

Scutellum slightly convex; triangular basal plate developed at its base; longitudinal, elevated keel beginning from basal plate reaching to apex. Frena developed as oblique, low sclerite on ventral surface of scutellum, reaching to 1/3 of length.

Venter of abdomen: Venter conspicuously flattened medially, base without distinct structures. Spiraculae large, distinctly elevated.

Male external genitalia: Pygophore (Figs 5–7) oval in dorsal view; external opening dorsal. Ventral wall slightly convex in posterodorsal view; dorsal 1/4 flattened, with sparse pubescence, delimited by low, wide ridge (Fig. 5).

Ventral rim slightly convex in dorsal view (Fig. 6). Infolding of rim wide (Figs 6, 7), almost at right angle to ventral wall, concave medially.

Dorsal rim convex in dorsal view (Fig. 6). Infolding of rim wide, at obtuse angle to dorsal wall, sublateral tufts of pubescence near external opening of pygophore (Figs 6, 7). Infolding convex medially, gradually concave laterally, where infolding merges with infolding of lateral rim.

Lateral rim convex in dorsal view (Fig. 6). Infolding of rim conspicuously wide, at right angle to lateral wall, with sparse pubescence (Figs 6, 7). Infolding concave medially, gradually convex ventrally, where infolding merges with infolding of ventral rim.

External opening in dorsal view without excavations for parameres (Fig. 7). Proctiger of simple shape (Fig. 6).

Paramere (Figs 8–11) with four rigid setae on beginning of hypophysis; apex of paramere directed ventrally in natural position in pygophore.

Phallus (Figs 12–14) with phallotheca strongly sclerotised on following parts: ventral side basally, dorsal side apically, and entire apex. Ejaculatory reservoir of complicated shape (not studied in detail) in middle of phallotheca.

Conjunctiva represented by membranous process (Figs 13, 14).

Vesica begins from middle of apex of ejaculatory reservoir, ending in secondary gonopore directed posteroventrally (Fig. 12). Strongly sclerotised, unpaired medial penial lobe surrounds vesica, only secondary gonopore left free. Medial penial lobe cylindrical (Fig. 12), closed on both sides except base of dorsum.

Phallus directed in natural position in pygophore anteriorly (phallotheca) and dorsally (conjunctiva and vesica).

Acknowledgments

I am grateful to Dr W. A. Dolling (Natural History Museum, London) for the loan of material. I thank Dr D. Osborn for critical reading of the manuscript.

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HUNTING WITH HIDES: ETHNO-HISTORICAL REFLECTIONS ON VICTORIA RIVER STONE STRUCTURES

KENNETH J. MULVANEY

MULVANEY, K.J. 1993. Hunting with hides: Ethno-historical reflections on Victoria River stone structures. *Rec. S. Aust. Mus.* 26(2): 111–120.

The remains of distinctive man-made stone structures exist throughout much of the Victoria River District of the Northern Territory. These features were constructed as hunting hides, utilised in trapping birds of prey. Aboriginal accounts reveal the hunting methodology to have been an extremely efficient and reliable means of procuring food. The technique employed appears to have been particular to the area, and was practised until relatively recent times. This paper presents oral accounts and an analysis of the function and use of these structures. Comments on the physical characteristics of such arrangements are made and related to a discussion of the formational processes of similar but natural features. This paper supplements an earlier study on the subject by Lewis.

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While undertaking field work during the late 1980s in the area of the Northern Territory known as the Victoria River District (VRD), the author was shown a number of stone features by local Aboriginal men, who held considerable knowledge of their use. These particular observations were made near the town of Timber Creek. At this time, a second researcher was documenting similar features in other areas of this region. In his article, Lewis (1988) describes these characteristic stone arrangements which relate to a specific resource exploitation strategy. Until recently the distribution of these stone structures appeared to be limited to areas associated with Ngarinman, Ngaliwurru and Bilinara language group territories. It is now evident that the construction and particular use of these stone features was much wider than originally postulated, though as yet still within a relatively small region of Australia (Fig. 1).

Ethnographic information obtained by the author from a number of communities in the VRD confirms the interpretation of these small, low circular features as hawk hunting hides. These observations were made while conducting research in relation to a claim by Aboriginal people, under section 50 (1) (a) of the *Aboriginal Land Rights (Northern Territory) Act* (1976), for land near the Northern Territory town of Timber Creek, and while documenting Aboriginal sacred sites in areas to the west.

Historical accounts and ethnographical sources indicate that trapping of birds and the use of hunting hides were activities practised across a wide area of Aboriginal Australia. The particular construction of the stone hides and the accompanying lure technique described in the accounts of VRD Aborigines was of limited distribution though, confined to the general VRD region. This paper in part attempts to explain reasons why this hunting method fell into disuse, and why hides have so far only been recorded in the Victoria River district.

Oral Traditions About Hides And Their Use

Aboriginal oral histories indicate that the procurement of birds of prey, in particular the black kite, *Milvus migrans* (colloquially known as the chicken hawk), by this method formed a major part of the meat component of the diet of VRD people until relatively recent times. As Lewis notes (1988: 74–78), Aboriginal people throughout this district have extensive knowledge of these stone features and the associated hide hunting strategies. Some older Ngaliwurru and Bilinara have themselves hunted the black kite and others of the hawk family in this way, and a number of younger people remember consuming catches made by their elders. At what date the procurement of birds by this method ceased is uncertain. People born in the mid 1940s recall that such practices were still in use during their childhood. To the west, in Mirriuwung and Gadjerong country, it appears that this practice did not continue far into this century. Major factors leading to the decline of this hunting activity have been access to a ready supply of food in the form of station rations and, more recently, the acquisition of firearms and the establishment of roadhouses. According to Jerry Jones Manjiari (pers. comm. 1987), a Ngaliwurru man residing in a camp outside Timber Creek:

> we can get chicken from Fogarty's Store, and anyway they taste better.

European awareness of the existence of these features dates back to the time of the first explorers in this region. However, it was not until much later that

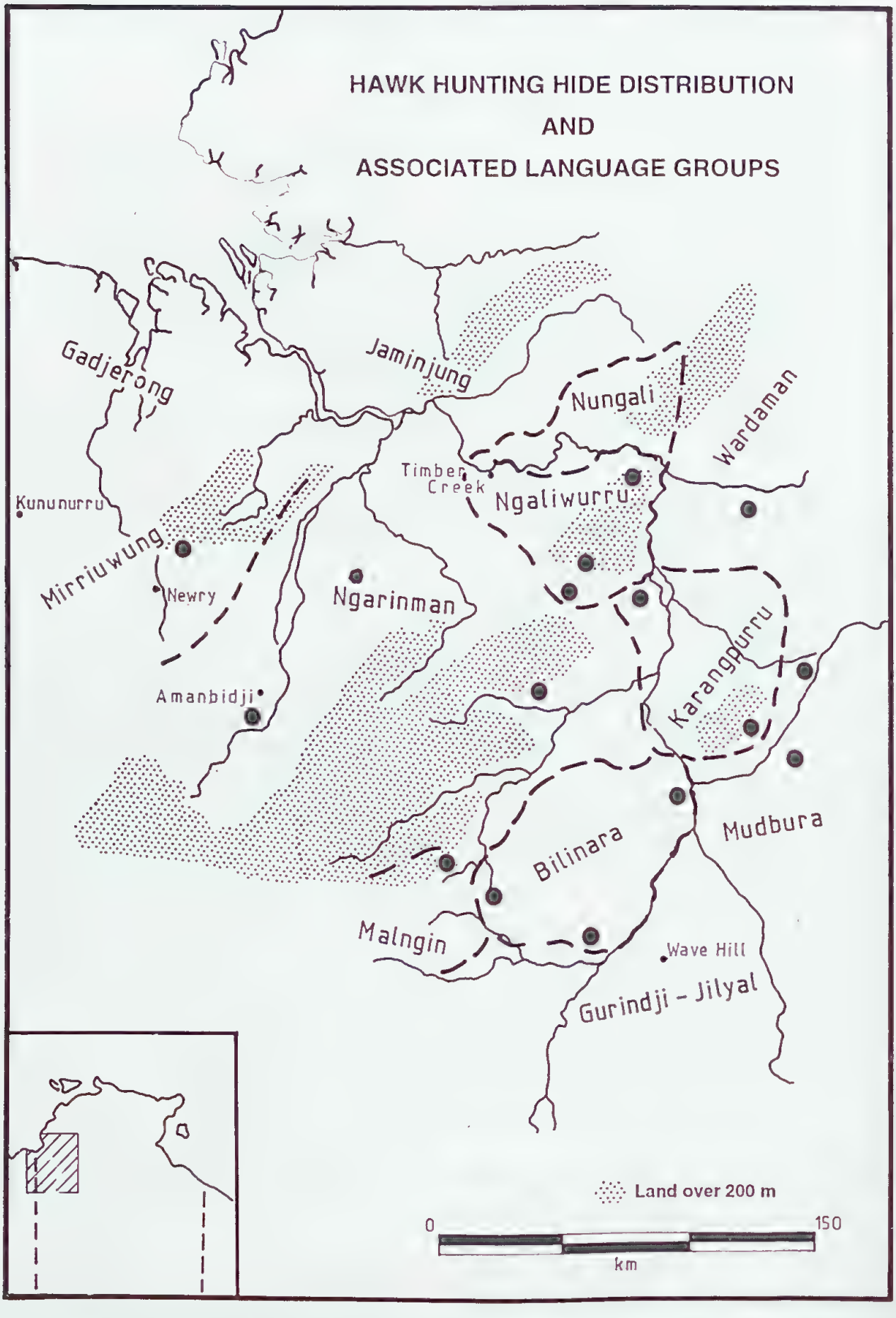

FIGURE 1. Map showing relationship of recorded hide locations and language group territories in the Victoria River District, as identified by the author. Some locations for hides taken from Lewis 1988: 78 (Map 1).

descriptions of these as hides and the associated hunting strategy appeared, albeit to varying degrees (Basedow 1925: 137; Browne 1895: 12; Buchanan 1933: 91; Linklater 1940: 8; Mathews 1901: 77). Judging from the content of their text, it is likely that some of these early accounts were second-hand, the authors having never witnessed the activity, nor spoken to the Aboriginal hunters. Nevertheless, the author's research concerning these features concurs on general principles with these historical accounts, and the consensus as to hunting methods within these texts is reflected in current Aboriginal accounts.

Preparation of the hides entailed the construction of a circular, or semi-circular, low, dry stone wall to a height of approximately one metre. Brush, sticks and loose vegetation (spinifex or other grasses) were laid across the top of the stone structure, forming the roof. One or possibly two men would secrete themselves within, and through a small opening in the roof, would thrust a stick, to which was bound or skewered a small bird. This bird was used as a secondary lure, and was caught with a throwing stick or stones (an activity at which young children are still proficient). Jerry Manjiari stated that a dead bird had the feathers removed, though this aspect of lure preparation has not been mentioned by other Aboriginal informants or in the historical accounts. It is worth noting Mathews' comment that the bait was partially roasted (1901: 77), a variation which has not been confirmed in current oral traditions. The use of small dead birds as lures has been observed elsewhere in Australia, though the employment of a twirling lure seems particular to the VRD. The use of tethered live decoys appears to have been a more common practice (Anell 1960). A fire made adjacent to the hide was the principal lure, the rising smoke attracting hawks and other birds to the vicinity of the hide. It is possible that some of the smoke signals recounted by Willshire in his travels through the VRD bush were these smoky hunting fires (1896: 51).

Accounts given by Jerry Manjiari and Bardi Jalokari suggest that at times two individuals would remain in the hide, one to twirl the lure, the other to catch and kill the attracted birds. Linklater also states that two people worked within the hide (1940: 8). Mirriuwung people also recounted that at times two hunters operated within the one hide. Other informants indicate that the hunting of hawks was a solitary activity, though several hides in close proximity could have been utilised in the one session. Most historical references refer only to one person being within the hide, an accomplice having lit the fire and removed himself from the area (Basedow 1925: 137; Mathews 1901: 77).

The hunter in the hide twirled the rod with the attached bird lure. Jerry Manjiari described the technique as follows (pers. comm. 1987):

> ... [he] rub with the long stick – and make it roll around ... so he's flick flick all the time – they [the hunters] used to keep this one flicking all the time – they can hear this big noise coming up – Ah! – they reckon a hawk coming up – they used to go steady and steady then – they used to pull it right back and they can see him coming right down – they used to pull it right down – he [hawk] try to grab – they used to grab him and pull him down... break his neck... they used to get him – they used fill it right up how much they sit down – they used to go about that much [chest high] they reckon – that's the story they been telling me.

References to a small bird (prepared or otherwise), suspended on a stick rotated by the hunter, are found in the oral accounts of other VRD Aborigines. With the increased, and extended, range of contact between neighbouring and more distant groups in recent times, it is more than likely that some oral traditions concerning this hunting practice have merged. People from different communities state that their knowledge was obtained either as direct witnesses, or from information passed to them as children. There are some obvious local variations; within Mirriuwung country people state that the hunters lay down within the hides, yet in all other areas, people indicate that the hunters sat or squatted. In other aspects the Mirriuwung accounts are strikingly similar, especially the twirling stick lure. Given the consistency in recounting this particular combination of technology by those who once used, or witnessed this method, it appears that the strategy was in general use among a large number of Aboriginal groups throughout the VRD. Unfortunately historical accounts do not elaborate on the matter of particular aspects, or detail. Description are given in general terms, using such phrases as 'exposed to view' (Browne 1895), or 'holding the bait' (Buchanan 1933, Basedow 1925, Mathews 1901). There are further references to small lizards or lumps of meat being placed either beside the hide, or on its roof (Anell 1960: 30–35; Buchanan 1933: 91; Mathews 1901: 77), but Aboriginal tradition suggests that a small bird attached to a stick was favoured as a lure.

The strategy was a successful and efficient hunting method. All accounts attest to the large numbers of birds caught in this way. In addition to hawks, other birds including crows and eagles, attracted by the smoke, were taken. The author was told that the hunting of hawks was undertaken with the certainty of obtaining meat. Obviously, after the initial construction of the stone walling, these structures could be reused. Minimal effort was thus required to procure the birds. This aspect of hide efficiency was stressed by Jerry Manjiari (pers. comm. 1987):

> that's where they used to get their food from – quick one – quick one to get him – you might find you go out hunting for kangaroo – sometime bad wind – wind blowing everyway – you got to have mud on you – well this one is quick way – for hunting food – just like getting chicken in the shop you know.

FIGURE 2. Maggie John (second from right) and other Mirriuwung women standing beside the remains of a hawk hunting hide, Newry station, N.T.

A similar sentiment was expressed by a Mirriuwung woman (Maggie John pers. comm. 1992), while we were inspecting one of these hides (Fig. 2):

> when they bin getting kangaroo nothing – come here – make him fire – get bird – 'nother one comes down get him – soon get big mob – walk back to camp, biggest mob tucker.

It is apparent from the oral tradition among the people of this part of the Northern Territory that they regarded the hunting of fowl by these means as an optimal strategy. Not only young hunters, but older, less agile men participated in the capturing of birds, bringing them back to camp by the armful. The procuring of meat in this manner required fewer skills than those for other hunting activities; all that was needed was a bait and some dexterity in grabbing birds. But while oral accounts suggest that hawk hunting by this technology was an important contribution to the subsistence economy, commentators on hunting and gathering technologies have tended to play down the success of this simple hunting methodology. In his thesis on hunting and trapping techniques employed throughout Oceania, Anell (1960: 51) regards the capturing of fowl by hand as inferior to other techniques generally employed in Melanesia:

> ... [Oceanic peoples] make use of other and more reliable methods which are wholly or in part lacking in Australia, eg. hunting with bow and arrow, snares, bird-lime and pole-nets, ... no time was wasted on the more uncertain and more time-consuming methods in practice of which the Australians have developed such mastery.

It is clear that knowledge of the technique, the location of hides, and oral traditions relating to the practice in the VRD, still exist. People retain many stories associated with the use of these hides; one humorous anecdote (Jerry Manjiari pers. comm. 1987) belies the danger of hunting hawks from hides which are often situated at the very edge of cliffs:

> this story my old father told me – there was him and Konkaman one time – they got into one of these [hides] – and they didn't kill this hawk properly – half dead – they didn't break the neck – they got up you know – he [hawk] was just going every way – he stuck there inside and they said now what we going to do – they just took off – this one old man said oh look you mob buggered everything up for us – because we can't get no more hawks – he went up and growled them – said you mob no good – we can't take you mob next time – that was finished.

Other stories describe dying hawks locking their talons into various parts of the anatomy of the hunters. These occurrences, and reference to other problems

such as lice (Lewis 1988: 76), seem not to detract from present Aboriginal notions of hawk hunting by the hide and lure technique. It is still held in high regard as a sure way of obtaining meat.

Aboriginal men, including Jerry Manjiari and Bardi Jalokari, have discussed these hawk hunting hides with the author. The Ngaliwurru word for the stone structure is *yarungindi*; the technique of twirling the stick was called *patakap-patakap* and *watakum*. Big Mick Kankinang (brother to Bardi Jalokari) however, gave the words *karakurlan* and *kirikirjiti* for the hide structure (Lewis 1988: 75). Further, Lewis termed the small bird lure itself as *perlkan*, whereas Big Mick used the term *djuru* to refer to the same object. It is possible that Big Mick was referring specifically to the small bird used, as the Ngaliwurru word *jura* equates with 'bird'.

One explanation of this variation in terms for the hide and the bait stick may be related to the linguistic properties of transferring naming concepts to English usage. For example, the Garawa of the Northern Territory's southern Gulf country call a flaked stone point *madjadja*. This name may also be given for a quarry site for such artefacts, or for a stone-tipped spear or a stone knife. Quarries may have their own locational title, and spears may be named according to the species of wood used for the shaft. Stone knives may be called *karnjirinya*, this word relating to the hair string and wax of the handle, rather than focusing on the stone blade. Both the word *majadja* and *karnjirinya* are correct names for the stone knife. It is therefore possible that this feature of nomenclature applies also the variation in terms relating to hawk hunting.

This pattern of multiplicity of words, encompassing morphology and/or methodology, is also found among the Bilinara people, whose country commences 80 kilometres south of that belonging to the Ngaliwurru. The Bilinara use the word *ngarunjuna* for the stone hide, and *kungkala* to describe the stick lure. In both instances these are not specialised terms, as *ngarunjuna* refers generally to any hut-like structure, regardless of the materials used in its construction. Loosely translated this word has the meaning of windbreak. Similarly, the term *kungkala* describes the rubbing, twirling motion employed when using the lure, and is the same term used for making fire by the drill method. This pattern of naming is the same as identified with both Mirriuwung and Gadjerong speakers (Kofod pers. comm.).

Distribution

Given the widespread distribution of birds of prey such as kites and eagles, and their behavioural traits in relation to smoke and fires, it is likely that these birds were exploited as a resource in other parts of Australia, though not as successfully as in the Victoria River area. Anell refers to a number of variations on the practice of hunting and trapping birds (1960: 50–51), but there is little in historical accounts, or Aboriginal traditions from other areas, to indicate hawk-hunting on a similar scale to that practised in the VRD area. Writing of the fortuitous shooting of a wedge-tailed eagle in Central Australia by Punch Arrerika (an Aranda tracker), Basedow stated that such birds were highly prized due to the rare occasions that they were obtained (1914: 93–94). A similar sentiment was expressed by a Jingili man (residing in Elliott), who stated the value in finding a fresh carcass of a chicken hawk (Abby Thomas Munamginji pers. comm.).

As stated, the use of stone-walled hawk hunting hides was widely practised throughout the VRD and may have occurred further afield. The ethnographer R.H. Mathews commented that this technology extended south, beyond the Tanami Desert to Lake Amadeus (1901: 76). It is also stated that the northern desert tribes of Western Australia employed similar strategies, utilising hides constructed of spinifex rather than stone (Basedow 1925: 138). There is no tradition of hawk hunting hides among eastern groups extending to the Barkly Tablelands. This is despite feathers of such birds being highly prized, and forming part of ritual paraphernalia in ceremonies. In parts of the Kimberley, including those adjoining Mirriuwung country, there is no record of the use of hides in trapping hawks. As with other fowl, hawks were obtained using a small pronged spear, boomerang, or throwing stick (Kaberry 1939: 14). These hunting techniques are among a wider range recorded by Anell (1960: 28–74), varying in materials and the forms of structures, the lures used, and methods employed in capturing the targeted bird species.

Lewis has identified the distribution of the hides as confined to an area chiefly within the Victoria River Downs pastoral lease, with several outliers (Lewis 1988: 78). However, the evidence of Mirriuwung and Gadjerong people, whose country lies some 150 kilometres to the north-west, is that these features and the associated hunting technology extended over a much larger area than was originally considered. The block-like sandstone, and to a lesser extent the basalt of this region, supplied a handy building material, which facilitated the development of this hunting technology. Knowledge and use of the general principles of this hunting methodology probably extended even further afield. It is likely though, that the combination of circular stone hides with the twirling of the suspended bird lure was a particular, efficient adaptation of the technique in the Victoria River District.

Circular stone features can be found throughout Australia, and many were probably used as hunting hides, most commonly in obtaining macropods. These

FIGURE 3. Carlton Gorge and Ned John (husband of Maggie) seated beside the remains of a hawk hunting hide, Newry station.

FIGURE 4. Jerry Manjiari demonstrating the twirling motion, standing beside a hide situated on an escarpment edge, Stokes Range, N.T.

features rarely show a distinctive form, and many could derive from natural formations. As an archaeological feature though, hawk hunting hide structures are distinctive to the Victoria River Downs region. Most of the hides in the area are constructed from tabular stone blocks (especially in the sandstone country) built to a height approximately level with the head of a seated man (100 cm). The structure is circular and may enclose an area sufficient to accommodate two individuals, plus space to store captured birds. It is estimated that a minimum internal diameter of 100 cm would be required, and more commonly they are in the vicinity of 150 cm diameter. Small, lower, circular stone features in the region are unlikely to have been utilised as bird hunting hides.

The hides were constructed at suitable vantage points where the stone blocks were present. The rugged dissected sandstone formation of the Stokes Range offers these conditions, and is likely to prove rich in hawk hides. Generally, the walls of these structures are one block in thickness (20–30 cm), and smaller stone may be utilised as fill or stabilising wedges. All hides viewed by the author (both by field observation and in pictorial records) do appear to have an entrance, the stone wall not completely enclosing (Figs 3, 4). This explains the 'horseshoe' term used in early descriptions of these features (Browne 1895: 12; Gregory 1884: 115). Even when the wall is partially destroyed or disturbed there remains a relatively clear area devoid of blocks. This entrance feature may therefore be one of the principal diagnostic traits in determining stone structures as hides.

The Stokes Range hides tend to occur near or on the edge of steep inclines, and Ngaliwurru men regard such locations as important in this hunting strategy (Fig. 4). These high and clear vantage points probably maximise the number of hawks attracted by the smoke lures. Elsewhere hides are situated on low stony rises, and in one instance, on Amanbidji Station, the hide is constructed out on the open ground away from the hills (Palmer & Brady 1991: 55). The occurrence of suitable building blocks seems to have been a primary consideration in positioning hides, and if the location also affords high visibility, then this clearly was a bonus. It could be expected that density of hides would increase where a combination of these factors is present.

As mentioned, naturally occurring features do exist which may confuse archaeological patterning. In fact, it is likely that some of the recorded hawk hunting hides are in fact natural features. Such natural stone formations can be found over much of the Stokes Range. They exhibit a number of characteristics which distinguish them from the constructed hawk hide. Akerman has observed (pers. comm.) that large trees may be the predominant cause for these formations. A tree growing in rocky country pushes up and forces out stones from the strata surrounding the trunk. The natural bedding of the strata then tends to slide back on itself, suggesting that artificial stacking has occurred. When the tree dies and decays, or is removed by fire, a characteristic circular stone wall-like structure remains. The floor is usually lower than the surrounding surface with a conical depression representing the area previously occupied by the tree roots. This particular feature is absent in the construction of hawk hides. Further, these naturally created features have been observed in progressive stages of formation.

In addition, one group of stone features recorded as hides, and shown to the author by a Ngaliwurru man, though clearly of human construction are not hides. Also confusing the pattern is the probability that natural formations could be utilised as hides. That this did occur was stated by Mundi, a Mirriuwung man from the Dunham River country, west of Kununurra, in general discussions concerning hunting practices. This man, now deceased, spent much of his time on Ivanhoe Station, and it was evident that he possessed considerable knowledge about these features (Kofod pers. comm.). It is likely therefore, that construction and use of stone hawk hunting hides did extend through western Mirriuwung country, though the only hides seen by the author are to the east, on Newry Station.

Early European Records Of Hides

Although identification of a stone hide is relatively simple, these structures exist in isolation, with no direct evidence that would indicate their function. In fact, without the ethnographic data, their identification as hawk hunting hides is problematic. The earliest records concerning these features were made during Gregory's North Australian Expedition of 1855–56. Gregory noted these stone structures on 1 December, 1855, and surmised from his knowledge of burial customs that they were used as temporary sepulchres (1884: 115). During an unsuccessful search for stray horses the expedition's artist and storekeeper, Thomas Baines, came across one of these hides and noted in his diary (Baines 1856: March 5):

> ... unable to find Gypsey, Polly and several more [,] saw a kind of loose wall and roof built beside a mass of rock and grass strewn in it but no sign of its having been inhabited or to show what use it had been put to.

A few days after this entry he prepared a watercolour sketch (Fig. 5), probably of this structure. His annotation in the bottom right-hand corner indicates that he adduced them to be associated with superstitious practices relating to recovery of health. In his published account Baines was less willing to speculate as to their function, simply stating that they did not

FIGURE 5. Copy of Bains' watercolour sketch of a hide, taken from Braddon 1986: 63. Original held by the Royal Geographical Society, London.

appear to have been put to any use whatever (Baines 1858: 7). Wilson, the geologist attached to the party, suggested that the structures were look-out stations, used when watching for kangaroos (Wilson 1858: 151). It is easy to surmise that the coming of these Europeans into this region would have been an extraordinary occasion, disrupting the regular pattern of subsistence. It is not surprising that members of the Gregory expedition did not witness the hides in use, and were thus unable to correctly interpret their function.

The hides recorded during the Gregory Expedition (1884) conform to the distribution described by Mathews (1901), Basedow (1925), and subsequently mapped by Lewis (1988: 78). This area, within the pastoral leases of Amanbidji, Victoria River Downs and Newry, has been occupied historically by a number of Aboriginal linguistic groups (Fig. 1). Even though the recorded distribution of these hides may be distorted by natural features, it is clear that the practice of hawk hunting with hides and lures occurred over a large expanse of the north-western area of the Northern Territory and part of north-eastern Western Australia, some 18,000 square kilometres in extent. This distribution is far wider than originally postulated by Lewis (1988). It is possible that such features may also occur in areas still remaining to be investigated, such as the country between the Victoria and Fitzmaurice Rivers.

In other regions, in particular that mentioned by Mathews (1901: 76), brush and spinifex would appear to be the only construction materials used, providing a less substantial, temporary structure. Identifying the existence of such features in these regions would be extremely problematic. Inspection of these constructions does not reveal any other material evidence associated with the stone structures. Roofing materials, a few feathers, possibly some blood, and nearby, a small pile of ash or charcoal, are all that would have been left after use. Given that some decades at least have passed since their use, it is unlikely that such material remains in evidence. In fact only one of the hides so far recorded still retains roofing material (Lewis 1988: 77). It is possible though, considering recent developments in the analysis of blood samples on ancient stone artefacts (Loy 1987), that traces of hawk (or human) blood could be detected. Nonetheless, interpretation would still remain inconclusive without the ethnographic data.

The Decline Of Hawk Hunting

It appears that the use of hawk hides ceased about 35 years ago, although in Mirriuwung and Gadjerong country the technique is said not to have been practised by the current oldest generation. This would place the decline in hawk hunting in this western area

of hide distribution at about 1910. Although Kaberry's (1939) accounts indicate that hides were not in use at the time of her research (1935), it is possible that the Mirriuwung man, Mundi, used the technology (Kofod pers. comm.). This would mean that in some areas of Mirriuwung country the hide and lure technique continued until much later. The varied pattern of continued reliance upon this technique after European contact in the region is possibly explained by local differences in attitudes towards Aboriginal people on stations throughout the region. While the establishment of the pastoral industry in region from the 1880s exerted a similar effect on local Aboriginal populations at a gross level (McGrath 1987, Rose 1991, Shaw 1986), the individual attitudes of particular station managers go some way towards explaining local variations in Aboriginal response and adaptation. Certainly Aboriginal reflections on past station people reveal harsher, less charitable relations in the eastern sector of where these hides occur, encouraging continued reliance upon hawk hunting to supplement the Aboriginal diet.

Other interrelated conditions affected particular Aboriginal responses in communities throughout the region. These factors include the advent of retail outlets following the introduction of a cash economy, the ready availability of food, coupled with the decline of interest in acquiring other hawk products for ceremonial purposes, and the introduction and widespread use of firearms. It is worth noting though, that although the use of rifles has made the hunting of most game far easier, the hide and lure technique remains more efficient for hunting hawks.

Nevertheless, while other traditional foods are often collected or hunted by the various communities in this regions, it is only hawk hunting that has dropped out altogether. There appears to be an acculturated response, acquired from Europeans, which has made hawk and crow flesh repugnant to younger members of those communities. In discussing the trapping of hawks and eagles, Buchanan (1933: 91) remarked:

> ... such meagre and repellent flesh seems hardly worth the trouble. But natives have infinite time and patience and, what is more essential strong digestion.

Such statements reflect the attitude of white station people of that era, and are likely to have influenced Aboriginal people living and working on these stations. Furthermore, in recent times, the use of the cotton or synthetic filling obtained from disposable nappies has largely replaced the use of bird down as body decoration during ceremonial activities. This has removed the necessity for acquiring large numbers of these birds, further contributing to the decline of hawk hunting.

Although hawk hunting has now ceased, knowledge of the specialised hunting technology is still retained by Aboriginal people in the VRD. This landscape is dotted with the characteristic stone hides, used in the development of the particular hunting strategy that was employed from west of Kununurra through much of the Victoria River drainage basin. Indications from Aboriginal sources make it evident that hawk hunting was undertaken to provide meat quickly and without great effort. Now that the flesh and other hawk bi-products, such as down, have modern equivalents which are readily available, the activity has lapsed. Knowledge of the hunting technique is retained, and the stone structures remain, but the incentive to utilise them has declined. The country store now fills their role.

Acknowledgments

I am indebted to Mr Kim Akerman, who not only inspired me to write this paper but gave many suggestions, and read the draft text. My thanks also go to Mr Bernard Higgins for the loan of published and unpublished material used in this paper.

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RADIOCARBON DATES FOR PREHISTORIC OCCUPATION OF THE SIMPSON DESERT

M. A. SMITH & P. M. CLARK

SMITH, M. A. & CLARK, P. M. 1993. Radiocarbon dates for prehistoric occupation of the Simpson Desert. *Rec. S. Aust. Mus.* 26(2): 121–127.

The radiocarbon dates reported in this paper are the first to become available for human occupation of the Simpson dunefield. They show that *Marapadi*, one of the small wells *(mikiri)* crucial for Wangkangurru occupation of the dunefield at the turn of the century, was in use about 2700 years ago.

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In this paper we report a series of radiocarbon dates for human occupation of the Simpson Desert and review existing archaeological evidence from the region.

The Simpson Desert, one of the great deserts of the world, consists of an immense dunefield, covering 159 490 km^2. This forms a broad triangle bounded by Lake Eyre to the south, the flood plains of the Finke and Macumba Rivers to the west, Goyders Lagoon and the flood plains of the Diamantina River to the east and the Central Australian ranges to the north (Fig. 1). It is the most arid part of the Australian landmass, with recorded rainfall at less than 100 mm p.a. and both rainfall variability and evaporation at extremely high levels (Anon. 1986). The region is dominated by parallel south-east to north-west trending dunes, 10–20 metres high and often running more or less unbroken for hundreds of kilometres. These are sparsely covered with spinifex (*Triodia basedowii*) or sandhill canegrass (*Zygochloa paradoxa*). Land systems and physiographic features of the Simpson Desert are described in more detail by Purdie (1984) and others (Gibson & Cole 1988). Graetz, Tongway, & Pech (1982) provide an ecological classification of the southern part of the region. Within the Simpson Desert there is a major contrast between pale dunes, rich in clay pellets, in the south-eastern part of the dunefield and the red quartzose dunes that form the greater part of the dunefield (Wasson 1983). Respectively these form the Karanguru and Wongkangurru ecological associations recognised by Graetz *et al* (1982). An important feature of the Karanguru association is the number of large playas within the dunefield (see Fig. 1). Loffler & Sullivan (1979) argue that these are remnants of a formerly much larger Lake Eyre whose boundaries are now obscured by dunes.

The southern part of the Simpson Desert was the territory of the Wangkangurru people, whose only permanent source of water was provided by a series of deep wells, called *mikiri*, which tapped subterranean water in shallow sand or gypcrete aquifers. With Wangkangurru guides, David Lindsay entered the heart of the dunefield in 1886 (Lindsay 1886, 1890) but Europeans did not successfully traverse it until the late 1930s (Madigan 1946; Colson 1940). The last of the Wangkangurru left the desert in the summer of 1899–1900 (Hercus 1985) but have provided detailed oral accounts of life in the *mikiri* country, its cultural geography, and of how people came to leave the desert. (Hercus 1985; 1989, 1990; Hercus & Clark 1986).

Fieldwork in 1990

The radiocarbon dates reported here (Table 1) are the first to become available for human occupation of the Simpson dunefield.

Following on from earlier archaeological reconnaissance in the dunefield (Hercus & Clark 1986), we were able to collect small samples for radiocarbon dating from intact hearths eroding at several sites in the Simpson Desert. Our aim was to begin the process of building a chronology for human occupation in the region. Previous work in the region (Hercus & Clark 1986; Davidson 1983) has relied on artefact typology to give an indication of the order of antiquity of occupation but work in adjacent regions (Smith, Williams & Wasson 1991; Veth, Hamm & Lampert 1990) suggests that this approach can lead to gross underestimates of age when compared to subsequent radiometric dating.

In isolation, radiocarbon dates for individual hearths are of limited value. Because of this the fieldtrip in July 1990 also aimed at determining whether key *mikiri* sites had sufficient stratified deposits to provide the basis for a more detailed look at their prehistory. This was found to be the case and it is hoped that a detailed study of two *mikiri* sites, *Marapadi* and *Palkura*, can be undertaken in the near future.

FIGURE 1. The Simpson Desert and places mentioned in the text. Playas and claypans within the dunefield are highlighted in black. Triangles mark archaeological sites mentioned in the text.

FIGURE 2. The broad well depression at *Marapadi*. View looking east, July 1990, with (from L-R) Luise Hercus, Bingee Lowe and Lockey Stewart. (M. A. Smith).

Mikiri wells

There were at least 18 *mikiri* wells in the Simpson Desert. These were the only permanent source of water in the region and were crucial for Wangkangurru occupation of the dunefield at the turn of the century. The most important historical account of the Simpson Desert wells and of the Wangkangurru *mikiri-nganha* people camped near them comes from Lindsay (1886). There is further information in Horne & Aiston (1924). The way of life of the *mikiri-nganha* has been described elsewhere by Hercus (1985, 1989, 1990; Hercus & Clark 1986).

How long the Wangkangurru have inhabited the Simpson Desert is unknown. Linguistic evidence suggests that the time necessary for the separation of Wangkangurru from Arabana, spoken to the south and southwest of the Simpson Desert, is within a thousand years (Hercus & Clark 1986:62). One thing is certain, the *mikiri* are the key to reconstructing the human prehistory of the Simpson Desert. The strategic role of these wells in local subsistence means that any evidence of changes in the pattern of occupation at these sites will have important implications for the prehistory of the southern part of the dunefield.

Marapadi

Marapadi or Murraburt is the westernmost of the *mikiri* wells (Fig. 2). Archaeological evidence of habitation is more extensive here than at the other wells so far visited. The most clearly defined of a series of hearths visible at this site was one (MPI/1) exposed in a deflated area amid a scatter of chipped stone artefacts and finely-fragmented bone on the south end of a dune about 260 m north-west of the well. On the surface MPI/1 (Fig. 3a) appeared as a charcoal stain, roughly oval in plan, measuring 430 x 560 mm. On excavation it proved to be a well-defined basin-shaped pit, 90 mm deep, dug into a finely laminated yellow dune sand. In cross-section a thin band of charcoal extended downslope representing minor reworking of the exposed surface of the feature. The pit was filled with finely comminuted charcoal. It contained no artefacts, burnt clay or shell but its morphology is clearly that of a hearth rather than a root or burrow (cf. Smith, Williams & Wasson 1991: 180–183). A sample of charcoal from the feature gave an age 2710+/–130 yrs BP (ANU-7683), showing that the *Marapadi* well was in use at sometime between 2450–2970 years ago.

Palkura

At *Palkura*, unlike *Marapadi*, archaeological material is concentrated within the broad depression of the well itself. Occupation debris is only sparsely scattered elsewhere. About 300 m southwest of the well, we found a hearth (PKA/1) eroding from sediments at the foot of a dune. It consisted of a patchy scatter of charcoal lumps over a roughly circular area 600–800 mm in diameter. Upon cleaning back the surface with a trowel much of this proved to be charcoal thrown out from a well defined fireplace (Fig. 3b). The latter was about 450–500 mm in diameter and consisted of a dense charcoal stain with large lumps of wood charcoal, up to 10 mm in diameter. This lay in a shallow basin, 70 mm deep, dug into a fine weakly laminated yellow dune sand. Although there was a thin scatter of chipped stone and finely fragmented animal bone on adjacent surfaces,

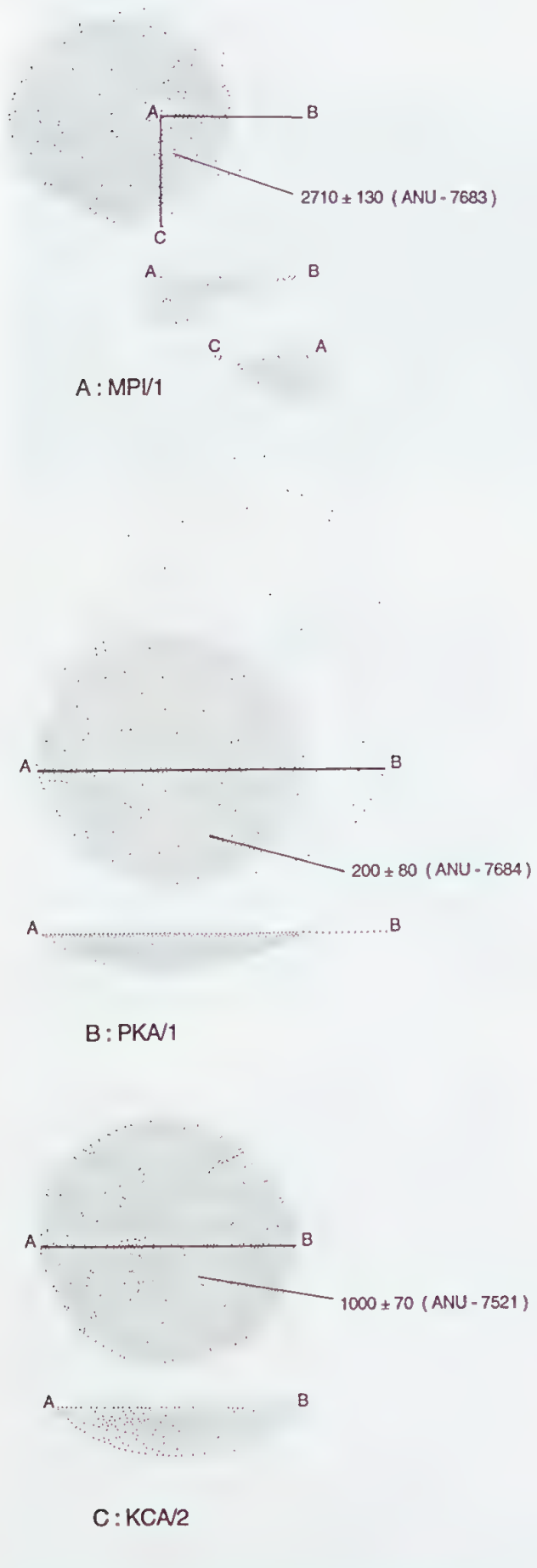

FIGURE 3. Plan and cross-section of excavated hearths.

there was no archaeological material apart from charcoal within the feature. A radiocarbon date of 200+/–80 yrs BP (ANU-7684) indicates that this hearth may date to the last phase of use of *Palkura* by Wangkangurru people.

A second feature, situated on the dune east of the well, was cross-sectioned but its distinctive cylindrical, slightly tapering, cross-section identified it as a tree-root rather than a fireplace (cf. Smith, Williams & Wasson 1991: 183).

Kadlalumpa

Kadlalumpa is one of the eastern group of *mikiri* wells. Amongst other archaeological material at this site there were four hearths eroding out in various parts of the site (eg. Hercus 1990 Fig. 2). One of us (PC) collected a sample from a hearth, labelled K4, on a separate visit in 1987. This was not necessarily the best preserved of the hearths but was sampled because its position with respect to the internal stratigraphy of the dune seemed to imply some antiquity. A sample of burnt sand and finely comminuted charcoal from K4 (ANU-7199) was submitted to the ANU Radiocarbon Laboratory but proved insufficient for dating. Although undated, the K4 hearth is of interest for its unusual morphology. In cross-section, there was no discernible vertical shape rather it formed a thin baked pavement or crust about 10 mm thick. The vesicular structure of this crust and the presence of baked clay and finely disseminated charcoal suggest that K4 was a fire constructed directly onto the soil surface at a time when this was slightly damp.

Other sites in the dunefield

Kuncherinna

One other site was sampled during the 1990 trip. This was at *Kuncherinna* where a series of hearths appeared to be eroding from a dune core, from buff sediments underlying a reddish palaeosol.

The *Kuncherinna* site borders a large claypan (Fig. 4). On either side of the claypan there are high longitudinal dunes. On the lower slopes of these there is a thin scatter of chipped stone artefacts which includes tula adzes. On the western side of the claypan, we noted eight hearths eroding from dune sediments. Two of these (labelled KCA/1 and KCA/2) were sectioned.

KCA/1 was manifest as a roughly circular patch of diffuse charcoal and baked earth, about 1.2 m in diameter. In cross-section it was a thin lense of charcoal-stained baked earth, 20 mm thick, with the vesicular structure familiar from the *Kadlalumpa* hearth. It contained some large pieces of charcoal, up to 15 mm diameter, but otherwise had no internal structure and contained no other occupation debris. As for the *Kadlalumpa* hearth, KCA/1 is probably the

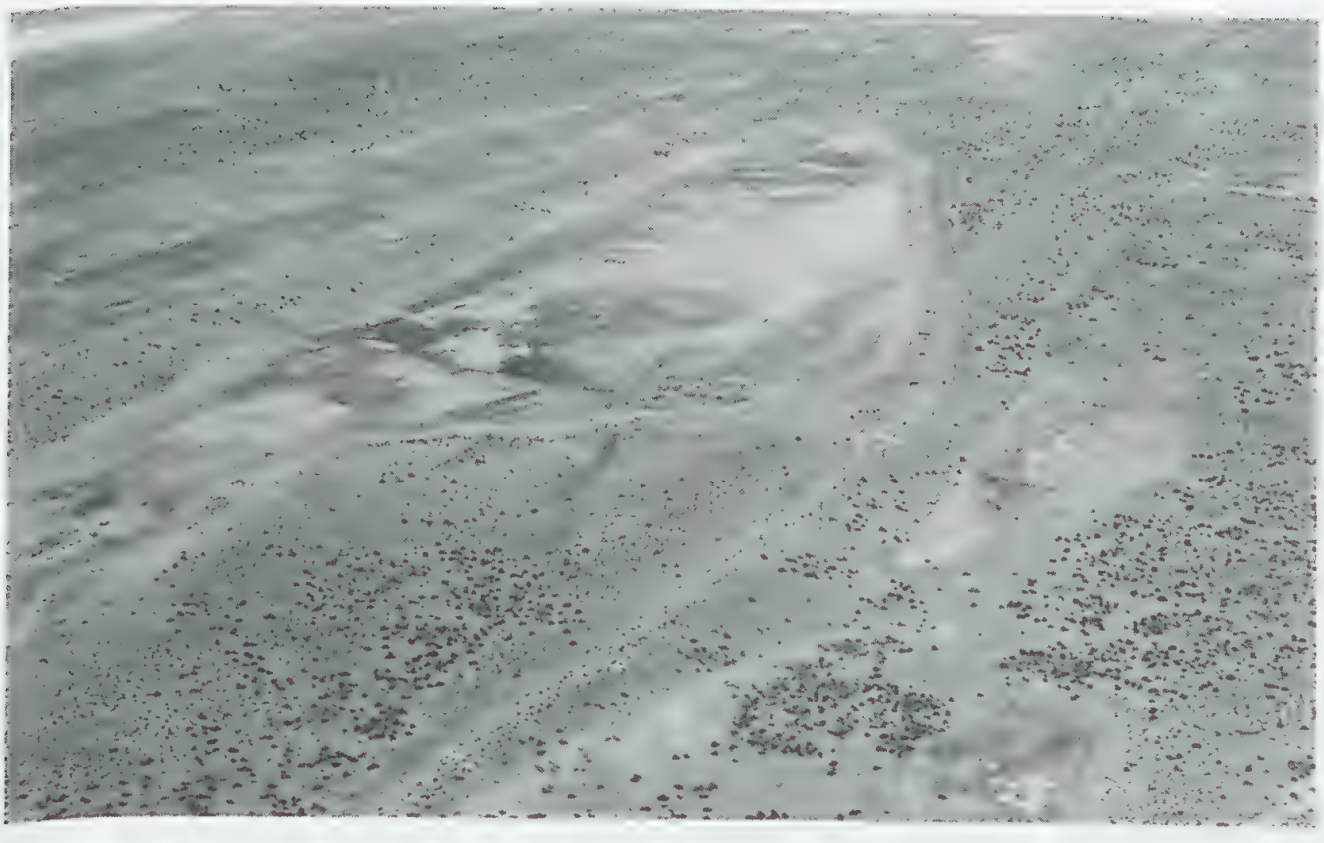

FIGURE 4. Aerial view of the Simpson Desert at *Kuncherinna* showing the large claypan and longitudinal dunes. View looking south-east, July 1990. KCA/1 and KCA/2 were situated on the western margin of the claypan, at the lower left of the photograph. (M. A. Smith).

remains of a fire lit directly on the surface of damp soil. Charcoal from this feature was radiocarbon dated to 1250+/–160 yrs BP (ANU-7520).

KCA/2 (Fig. 3c) was a small sharply defined fireplace in a basin shaped depression about 450 mm in diameter and 90 cm deep. This was dug into the surface of an indurated pale yellow clayey sand, topographically below a reddish palaeosol. It contained abundant large pieces of charcoal as well as finely comminuted charcoal. Charcoal from this hearth gave a radiocarbon age of 1000+/–70 yrs BP (ANU-7521), a result which overlaps with ANU-7520 if these dates are taken at two standard deviations.

These results indicate that the hearths at the *Kuncherinna* site are dug into the eroding surfaces of the dunes rather than contained within the Pleistocene sediments. The closely comparable ages obtained from two hearths situated at least 100 m apart raises the possibility that the remains at *Kuncherinna* record a single occupation, or closely spaced occupations, rather than an accumulation spanning several millennia. Further dating of hearths would be necessary to establish whether this is indeed the case.

Dated sites on the margins of the Simpson Desert

Although some archaeological reconnaissance has also been carried out in the northern part of the Desert, near the Toko Ranges by Davidson (1983) and at Geosurveys Hill by N. B. Tindale (Anon. 1962), the only other radiocarbon dates presently available for occupation of the Simpson Desert are from the western and north-western margins of the dunefield.

Oolgawa waterhole

During a geomorphic study of the Simpson Desert, R.J. Wasson identified several hearths exposed in the northern end of a longitudinal dune (Stockyard Dune) where it encroached upon the active floodplain of Adnalgowara creek (Wasson 1986: 63; Wasson, pers comm.). Charcoal from the hearths gave radiocarbon dates ranging from 2000–3000 years BP (Table 1). By chance the South Australian Department of Mines sampled the same features and obtained closely comparable radiocarbon dates ranging from 2500–2700 years BP. These dates serve to demonstrate use of productive flood plain habitats (Macumba ecological association) on the western margin of the dunefield at about the same time as we have evidence that *Marapadi* was in use.

Therreyererte

Therreyererte is a large open site on an alluvial fan on the northern edge of the Rodinga Range. The latter is a bold sandstone range rising abruptly from the dunefield in the north-western part of the Simpson Desert, dividing a small outer dunefield of about 1500

TABLE 1. Radiocarbon dates for sites in the Simpson Desert. Dated material was charcoal from hearths, except in the case of *Therreyererte* where detrital wood charcoal from an archaeological deposit was dated.

Site	Feature	Sample Code	Conventional Radiocarbon Age (years BP)	Reference
Marapadi	MPI/1	ANU-7683	2710+/-130	this paper
Palkura	PKA/1	ANU-7684	200+/-80	"
Kadlalumpa	K4	ANU-7199	small sample	"
Kuncherinna	KCA/1	ANU-7520	1250+/-160	"
Kuncherinna	KCA/2	ANU-7521	1000+/-70	"
Oolgawa WH		ANU-2838	1900+/-200	Wasson pers. comm.
"		ANU-2836	2220+/-100	"
"		ANU-2837	2840+/-80	"
Therreyererte	Z90/6	SUA-2520	400+/-50	Smith 1988
"	Z90/10	SUA-2519	1830+/110	Smith 1988

km² from the main body of longitudinal dunes. A small excavation at this site in 1986 (Smith 1988: 292) revealed a stratified occupation deposit underlain by red aeolian sand. The occupation is dated at two points by radiocarbon samples to 400+/–50 yrs BP (SUA 2520) and 1830+/110yrs BP (SUA 2519). By extrapolation, the basal age of the occupation deposit is about 3000 yrs BP at this site. This again suggests some parallel with the radiocarbon date for *Marapadi* but it is worth noting that the major period of use of *Therreyerte* did not begin until about 570 yrs BP.

Discussion

The radiocarbon dates reported in this paper are the first step towards establishing a chronology for human occupation of the Simpson Desert. They show that at least one of the *mikiri* wells was in use about 2700 years ago. This has implications for the prehistory of the region. Firstly it suggests that the locations of some of the Simpson Desert wells were known at this time. Secondly, it indicates that the shallow groundwater tapped by the *mikiri* wells existed at this time. Thirdly, if current views on the nature of these shallow aquifers are correct, it points to the likely availability of such groundwater earlier in the Holocene. As the *mikiri* tap groundwater supplies directly recharged by rainfall in this part of the dunefield they are presumably sensitive to long-term changes in regional rainfall. Given that the period around 3000 BP was the driest phase of the Holocene (Singh 1981; Singh & Luly 1991), it is possible that shallow groundwater would have also been locally available as early as 6–7000 BP. Whether or not humans occupied the dunefield at this time is unknown but in this context it seems likely.

The date of 2700 yrs BP for *Marapadi* also seems to coincide with evidence of use of the extensive floodplains on the western margins of the dunefield and the first phase of use of *Therreyererte* in the north-western part of the dunefield. Whether the apparent visibility of sites at this time is simply fortuitous, whether this was a short-lived period of greater human activity in the region or whether it marks the beginning of more intensive use of the major dunefields along the lines suggested by Veth (1989) will require more evidence to determine.

While it might be tempting to see the evidence from *Marapadi* as reflecting a broadly similar pattern of occupation of the dunefield to that recorded for the Wangkangurru at the turn of the century, the limited nature of the evidence prompts caution. Isolated radiocarbon dates on hearths and fireplaces cannot tell us whether use of the wells at this time was more, or less, itinerant than that recorded historically, nor whether use of the wells continued without major interruption from 2700 yrs BP until 1899–1900. Fortunately the presence of apparently stratified occupation deposits at some *mikiri* sites, together with an abundance of faunal remains and imported stone provide an opportunity to investigate prehistoric use of these key wells and the subsistence activities and external contracts of the desert Wangkangurru.

Acknowledgments

The authors thank Linda Crombie (Birdsville) for her support and the Aboriginal Heritage Branch (Department of Environment and Planning, South Australia) for formal permission to collect radiocarbon samples from archaeological sites in the Simpson Desert. Further information on the *mikiri* and *Kuncherinna* sites is held in the site register maintained by the Aboriginal Heritage Branch. We also wish to thank our companions in the field; Luise Hercus, Vlad Potezny, Bingee Lowe (Finke) and Lockey Stewart (Hamilton). The assistance of Vlad Potezny in relocating the *mikiri* sites was crucial to success of the fieldwork reported here. R.J. Wasson generously supplied information on the radiocarbon dates from Oolgawa waterhole. We thank Luise Hercus, Roger Luebbers, Mike Morwood, Vlad Potezny, Peter Veth and Bob Wasson for commenting on an earlier version of this paper.

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'THE INHABITANTS OF COOPER CREEK': A PART TRANSLATION OF CARL EMIL JUNG'S 'AM COOPER CREEK'.

C. W. NOBBS

NOBBS, C. W. 1993. 'The Inhabitants of Cooper Creek': A part translation of Carl Emil Jung's 'Am Cooper Creek'. *Rec. S. Aust. Mus.* 26(2):129–138.

This paper provides an introduction to the writings of Dr. Carl Emil Jung who travelled widely in Australia between 1865 and 1876. He then returned to Germany and published many works largely on the European colonies in Australia and the Pacific region. Particular reference is made to his writings on the Aborigines of South Australia. The paper includes a translation from Jung's article 'Am Cooper Creek' (1878), an account of his contact with the Aborigines on the Cooper Creek in 1865.

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Carl Emil Jung's Writings On The Aborigines Of South Australia

By 1860 the colony of South Australia was well established, and had a large German population living in and around Adelaide. Reports from the German communities about their successes, particularly in the acquisition of land and new freedoms, and about their isolation, were sent back to Germany to urge friends and relatives to join them in South Australia. By the end of the nineteenth century approximately 18 000 Germans had emigrated to the colony. Mainly consisting of farmers, tradesmen and their families, they also included a small number of professional people (Harmstorf 1976: 35):

> Most of the professionals were pastors and missioners of the Lutheran Church, but around the year 1848, with its abortive liberal revolutions in various parts of Europe, including the German states, came a sprinkling of men who for want of a better term may be called intellectuals, men who had received some form of tertiary education in Germany.

Dr. Carl Emil Jung, who had received a Doctor of Laws degree from either Göttingen or Jena University and travelled to South Australia in the late 1850s, was one of these 'intellectuals'. The earliest record of Jung's activities is his account of the time he spent as a manager of stock on the Dewalla Creek in south-western Queensland in 1865. Very little is known of his movements over the following seven years. In 1872 he was resident in Tanunda, South Australia, and applied for a licence to work there as a teacher.[1] He had the support of 'well educated' Germans like Martin Basedow, who has been described as 'an outspoken advocate of what was called "progressive education" at the time' (Harmstorf 1975). Basedow served briefly as the South Australian Minister for Education and was also the proprietor of Australia's largest German newspaper, the *Australischer Zeitung* ('Australian Newspaper').

In January 1873 Jung was appointed French Master and Assistant in the Boarding House at the Church of England Collegiate of Saint Peter in Adelaide, and in December accepted a German Professorship there.[2] He resigned in April 1874 upon appointment as Inspector of Schools in South Australia. This gave him the opportunity to travel to all parts of the state. He resigned from this position in December 1876, and soon after returned to Germany. The *Neu Deutsch Zeitung* ('New German Newspaper') of January 1876 reported that (p.4):

> Our fellow countryman Dr. C. Jung has given up his position as School Inspector because family matters compel him to travel to Europe. Dr. Jung, as we hear it, intends to familiarise himself with the new education system during his stay in Germany and to utilise the results of his research upon his return to South Australia.

Jung did not return to South Australia. During the following years though, he wrote many articles and several books on the European colonies in the Pacific region. Jung published three works based specifically on his contact with the Aboriginal people of South Australia.

Soon after his return to Germany Jung published 'Zur Kenntnis südaustralischer Dialekte' ('Towards a Knowledge of South Australian Dialects') in the *Journal of the Geographical Society of Leipzig* (1876). The title suggests an early analysis of the dialects of the South Australian Aboriginal people, but the article is not yet available in Australia. Two further accounts of his contact with the Aboriginal people of South Australia were published in the *Journal of the Geographi-*

[1] Records of the Central Board of Education, 1872: No. 50. Entry No. 2083, GRG 18, State Records Office.

[2] Minutes of the Council of Governors, the Church of England Collegiate of Saint Peter, Adelaide, 8 December 1873.

cal Society of Halle. The first article, 'Die Mündungsgegend des Murray und ihre Bewohner' ('The Murray-mouth Region and its Inhabitants') appeared in 1877 (1877a), followed by 'Am Cooper Creek' ('On the Cooper Creek') in 1878. These were based on first-hand observations, supplemented by information from the missionary George Taplin and, possibly, the police-trooper Samuel Gason.

In 1877 Jung also delivered a short paper titled 'Schamanismus der Australier' ('Shamanism of the Australian Aborigine') to the Anthropological Society of Berlin in which he described the role of magic in the beliefs of the Diyari people of the Cooper Creek. This appeared in the *Proceedings of the Anthropological Society of Berlin*, (1877b) and was also published in *Ethnological Journal* in Berlin. Another article 'Aus dem Seelenleben der Australier' ('From the Spiritual life of the Australian Aboriginal') published in the *Journal of the Geographical Society, Leipzig* (1877c), is not yet available in Australia.

In the same year, Jung also published two articles in *Globus*, an illustrated journal for 'Länder and Völkerkunde' ('Lands and Ethnology') which gave particular consideration to articles by specialists in anthropology and the ethnology of different countries. 'West Australien. II. Die Ureinwohner' ('Western Australia. II The Aboriginals', 1877d) is an ethnography of the Western Australian Aboriginal people in which Jung gave a detailed description of the people who lived in the north and south of the state. This included details of their housing, clothing, utensils and weapons, foods, social organisation and religious beliefs. He visited the prison on Rottnest Island which held 67 Aboriginal prisoners, many of whom had killed someone under tribal law and were subsequently incarcerated.

At the time of Jung's visit to the Catholic Mission of New Norcia, which was under the administration of Bishop Calvado, 34 Aboriginal adults and 26 children were living there. They were taught to read and write and given instruction in Christian beliefs with mixed results. Jung noted for example, that the Aboriginal residents believed that eating and drinking epitomised the way to salvation, as signified by the images of full-bodied angels, whom they said 'always had a full stomach'. They also heard parables from the bible and understood them literally: sheep went to heaven for example, but it was not clear why their animals (the emu and the kangaroo) were not to enjoy the same good fortune (Jung 1877d: 346–356; 365–367).

'Die Zukunft der Australischen Eingeborenen' ('The Future of the Australian Aborigines', 1877e) described the plight of Aboriginal people in each state and the various government policies and attitudes towards them at the time. Jung began by noting the lack of interest from official circles in getting to know the languages, customs and habits of the Aboriginal people. He acknowledged the importance of records left by the missionaries, the accounts of travel by explorers which reported their contact with the Aborigines in different regions, and also the detailed and reliable reports about Aboriginal tribes in the east, south and west of the country which came from the settlers and visitors to this land. By comparison, wrote Jung, the governments in each state had taken no steps to use people knowledgeable in ethnology to collect reports on the fast disappearing Aboriginal tribes. He noted approvingly that at least two colonial governments had taken the matter in hand. South Australia's Governor, Sir Anthony Musgrave (Jung 1877e: 219–222), had expressed the urgency of collecting:

> as quickly as possible, information about the languages, traditions and customs of the existing tribes, before they disappear from the earth as they have in other regions.

Jung also mentioned the establishment of a commission in Queensland with the purpose of investigating the position of the Aboriginal people and the possibility of 'civilising' them. The commission included the well-travelled explorers A. C. Gregory and W. Landsborough, as well as Bishop Hale who had already worked extensively among Aboriginal people in South Australia (Jung 1877: 235–237).

In 1879 Jung published 'Australien und Neuseeland' ('Australia and New Zealand'), an historical, geographical, and statistical sketch with 10 illustrations. In the introduction to the first edition of this book, Jung stated that 'the Australian colonies had in recent times aroused a lively and justifiable interest'. During the preceding ten years the large-scale migration to countries about which the Germans had little, if not out-dated knowledge, created a desire for more precise and current information. Their best geography text books were inadequate and geographic magazines did not provide the whole picture. Jung believed he could correct this deficiency and explained his purpose, using the third person (Jung 1879: iii–iv):

> It is the intention of the author to publish a comprehensive work on the Australian colonies. As a result of the participation of the German Reich in the International Exhibitions held in Sydney and Melbourne, a lively interest has been generated amongst many Germans who express the wish to obtain an up to date knowledge of the regions where it is hoped German industry can win a respectful place. In short, it appears advisable to draw up as quickly as possible, in a comprehensive way, sketch plans of existing conditions in those colonies.

The author's main purpose has been: to describe the economic conditions of the land at this time, as completely and objectively as possible in the limited space available. That is why he has allocated only limited room to the chapters on geography and ethnography. Instead he hoped to give the statistical data the desired comprehensiveness.

His stay in Australia extended over 19 years, and many times he travelled in all the colonies, almost to

the heart of the continent. For several years he was in a responsible position as government officer. This experience enabled him to obtain a detailed knowledge of the land and its inhabitants.

In this fact-filled publication Jung described the discovery and settlement of Australia and New Zealand, their physical features, and included chapters on their industries and populations.

Jung's comprehensive work 'Der Weltteil Australien' ('The Australian Continent') was published during 1882–1883 in four parts, as volumes VI, VIII, XI and XII of a series titled 'Das Wissen der Gegenwart' ('The Knowledge of the Present'), published by the German Universal Library for Education. Jung's volumes offered a broad perspective on geographical features and the impact of settlement in the region and included detailed information on the native peoples of the Western Pacific and Australia. Two of these illustrated volumes included ethnographic detail on Australian Aborigines: Part 1 (Volume VI), 'Der Australcontinent und seine Bewohner' ('The Australian Continent and its Inhabitants'), and Part 2 (Volume VIII), 'Die Kolonien des Australkontinents und Tasmanien. Melanesia.' ('The Colonies of the Australian Continent and Tasmania. Melanesia.'). Parts 3 and 4 (Volumes XI and XIII) were devoted to Melanesia, Polynesia (including New Zealand), and Micronesia. An abridged version of the complete work also appeared in English, published by W. Swan Sonnenschein in London in 1884.

Jung wrote two articles, both under the title of 'Deutsche Kolonien' (German Colonies) published in 1884 and 1885. The first was described as 'an article to improve the knowledge of the life and work of our fellow countrymen or "Landesleute" on the land in all continents' (Ferguson 1941–69: 190). The second made 'particular reference to the newest German acquisitions in West Africa and Australia [sic]' (Ferguson 1941–69: 190). Jung's 'Australie en Tasmania' ('Australia and Tasmania') was also republished in a Dutch edition in 1885. This would seem to be a translation of Jung's publication of the same title from 1882–83.

Jung's ethnographic writings reflect the dominant influence of his geographic studies. He was prepared to attribute the major differences which he observed between Aboriginal groups to geographic factors. In his introduction to 'The Murray Mouth Region and its Inhabitants' (Jung 1877a), he wrote that 'the characteristics of Aboriginal people are essentially limited by their geographical position and the productivity of the land' (Jung 1877: 24–47). He cited the examples of the Aboriginal people of Eyre Peninsula who were of a 'crooked stature', and the Aborigines of the drought-stricken plains of Western Australia who lived in a 'wretched state'. To these he contrasted the Aboriginal people of the Murray River who profited from an abundant supply of fish.

Jung went on to describe the geography of the Murray Mouth region, then provided an ethnography of the Narrinyeri people who lived there. A map showed the location of the Mission, the small towns to the north and the 18 clans of the Narrinyeri. His occupation as Inspector of Schools had enabled him to visit the area several times and to meet the Reverend George Taplin at the Point Macleay Mission. Jung's description of Narrinyeri customs and religious beliefs was largely based on Taplin's work. Whilst he acknowledged the importance of Taplin's records and oral information, Jung claimed that his own observations led him to different conclusions. For example, he included a Narrinyeri grammar in the article, but argued that Taplin's description of the language as very highly developed had been unwarranted.

Jung's 'On the Cooper Creek' was published in four parts, dealing with the Geography, Plants, Animals, and Inhabitants. Jung gave a detailed description of the peculiarities of the geography, flora and fauna in the region and changed to a narrative style in the fourth part to describe his contact with the Aboriginal people of the area. This account, as translated below, included descriptions of the Aborigines' clothing and decorations, and a rain-making ceremony. The similarity of these descriptions to the observations of Diyari Aboriginal people made by Samuel Gason, a police trooper stationed at Lake Hope in 1864, are remarkable (Gason 1879). Jung's description of the rain-making ceremony is identical both in form and content to Gason's and they both provide very similar descriptions of the Aboriginal people's ornaments. It is difficult to decide whether Jung used Gason as an unacknowledged source or whether his contact with the Yawarrawarka and Yandruwantha people near Innamincka, revealed distinct similarities in dress and custom.

Jung's description of the Aborigines of Cooper Creek was one of the earliest to be recorded, coming as it did just three years after the Burke and Wills expedition had failed there. Alfred Howitt's initial account of the Aborigines of the region, recorded during the Burke and Wills Relief Expedition, was not published until 1878, the same year as Jung's publication. It is likely that Jung's account, published in Germany, added further encouragement to German missionary interest in Central Australian Aborigines, as already expressed in the foundation of Lutheran missions at Killalpaninna (1866) and Hermannsburg (1877). His work would have been read widely in academic circles and no doubt by Erhard Eylmann, a German doctor with an interest in 'Anthropogeographie'. Eylmann made several visits to Australia between 1896 and 1902 and published the results of his anthropological research in the classic 'Die Eingeborenen der Kolonie Südaustralien' ('The Aborigines in the Colonies of South Australia', 1908). Eylmann was certainly familiar with Jung's writings

on the Australian Aborigines and these may in fact have provided a direct impetus for his work.

'The Inhabitants Of Cooper Creek'

It was an unusual occasion that brought me to this region. Today the land is fully occupied, surveyed (though in a rough way) and leased to pastoralists who appear to make good business there. In those times the Cooper Creek was a goal reached only by explorers. It was better known than many other rivers nearby, for the tragic fate of Burke and Wills had vested it with lasting interest.

I was at the time stationed on the Devalla Creek, south-east of the Wilson River. In those times, the oldest colonists warned of long periods of drought in which all water evaporated, all vegetation spoiled, and both the indigenous and introduced animals perished. I was of the opinion, as were many others, that settlement had overcome this sad phase of existence of the colony. That danger was not to be feared any more, and the squatter pushed irresistibly further and further forwards: at first with herds of cattle, then sheep. The search after grazing places was an occupation, and the sale of such practical knowledge became a source of income for more than one enterprising Australian pioneer. Even though moderate rain fell we still believed that the climate had changed for the better.

The year 1865 destroyed this illusion with a rough hand. The rainfall of the preceding years had been lighter in the inner districts, and now the eternally clear sky, scarcely covered by a cloud, was barren. All the waters dried up, and soon the last traces of vegetation were consumed down to their roots. The bodies of dying stock covered the plains, and the few waterholes became poisoned through their decomposition. In the caves and ravines of the distant mountains the lives of the indigenous animals ended.

The only trading place for this region was Fort Bourke. A German named Becker owned the store, in which everything could be found. There were extensive stores catering for the body's necessities including food and toiletries. The store, to use an expression used commonly by sailors and adopted by the squatters, held everything 'from a needle to a sheet anchor'. Between Becker and I lay a wide wilderness in which only isolated oases remained on the Paroo and the Warrego. These were the location of police stations which also served as post offices to which a small supply of letters and a plentiful supply of newspapers and monthly journals were brought out by dispatch rider from Bourke every 14 days. Otherwise the traffic was closed. Wool, which was sent to Bourke on heavy carts with great danger to the bullockies' lives and with the forbearance of the draft oxen, rotted outside under the sky because the store-owners refused to take it into their warehouses. Then 'cui bono', or 'to what purpose'? The shallow Darling could be crossed over on exposed reefs, and for a long time no steamers had travelled on it. The worth of the wool was less than the cost of overland transport to Sydney.

We were isolated, with only a few neighbours on the Wilson. The waterholes on Devalla Creek began to dry up. The dams built at great cost stood there useless, their reservoirs empty. The question of where to go to save the lives of the cattle and sheep came closer to me every day. To retreat was unthinkable, as the route to the Darling was barren. The only hope lay to the interior. For the 12 000 sheep there was soon a solution. A long deep waterhole on the Wilson, a 'billabong', offered itself to them. But cattle will not stay where sheep graze, and I had to go further. The only place was on the Cooper. A broad waterless stretch of torn black expanses and steep red sandhills lay between the Cooper and our stock. Although the numerous tribes of Aborigines living there would not welcome our arrival with friendliness, the attempt had to be made.

It was made and achieved despite countless difficulties and real danger to life because of water shortages. The animals, frantic with thirst, had almost forced their return to the abandoned waterholes over our bodies. Never will I forget that feeling of escape from extreme danger and the elation that accompanies achievement of a rare and risky undertaking when, on an arduous February night, I discerned in the bright moonlight the dark, dim line which was the Cooper. It was probably the first time a loud and cordial 'hurrah' had resounded through this wilderness. The pad which the camels of Burke and Wills' calamitous expedition had pressed into the soft earth was still clearly visible, and often served as a guide to us. This pad made a melancholy impression on my people and intensified the feeling of our predicament: we could read the story in the signs left behind on the Cooper. Burke and Wills returned to this place from the Gulf of Carpentaria only to become bitterly disappointed. Upon their arrival they found, to their horror, that the camp was deserted. The sombre green leaves and the brown raw bark of the trees, the black furrowed earth, and the deathly stillness all around were passing features and colours of a picture that appeared before our souls. We moved further downstream, and on a marvellous lake-like part of the river erected our camp. Mighty eucalyptus trees hemmed the high southern bank, while on the other side magnificent quartz sandstone outcrops completed the view. The bark of the trees carried the initials of all who had visited the creek before us. Not many, but names well known to Australian history.

We had with us only a small tent and meagre supplies on the pack saddles of our horses. The ground was too rough, and the route too difficult, to have risked taking a wagon. The tent served as our store-

FIGURE 1. Example of a *Thippa*, a decoration made from the tails of the extinct rabbit bandicoot. Collected by R.T. Maurice, Cooper's Creek. A2990, South Australian Museum.

FIGURE 2. Example of a *Mandamanda*, a woman's girdle. Collected by J.G. Reuther, Killalpaninna Mission. A2890, South Australian Museum.

house. The stores were meagre: blankets, clothes, a half sack of flour, a few sacks of sugar, preserved fruit and fish, and some tobacco and matches. The flour was abominable. We had secured it on credit from a settler on the Barcoo. God knows how long it had been stored by him since being purchased from some trader who should have sold it only as pig food. Half of it consisted of maggots. One of the indispensable foodstuffs missing was salt. We crushed enough from an abundant supply in a nearby salt creek, but soon found that it was unusable. The meat from our slaughtered cattle spoiled, and no one liked to eat the salted or 'jerked' beef. But the plentiful supply of meat which we could not handle was not wasted: we were not alone.

Most certainly our arrival had been awaited for some time. The Australian Aborigines were informed of our movements in advance by their peculiar telegraphy using smoke and fire. They were the lawful owners of the hunting grounds which I claimed for my cattle. When we arrived, there was not a soul to see and no tracks betrayed their presence. Yet they were around us, and nightly watched our camp without us seeing their tracks. The bushes which they bound on their feet completely swept away their footprints in the soft ground. My black companions did not want to acknowledge their presence, although they probably perceived much earlier and more easily the crushed Salsolaceen (buckbush or 'rolly-polly') and broken bushes which my assistant, Swanhill Jack, with his reliable skills as a bushman, soon drew my attention to. I gave orders that nobody should go away from the camp at night without first informing me of it. Nevertheless, one of my best men almost fell victim to a bullet from my rifle because of his sin of omission. The next morning showed how closely the Angel of Death had passed over him.

Finally they came. We had meat to throw away, and the blacks were hungry. They did not dare lay hands on our cattle (as they probably would have liked to), because they knew too well the sharp noise of firearms and its significance. They had, without a doubt, heard how the settlers in Queensland took revenge on those who stole their property, and they therefore preferred to come forward at last. Perhaps they were encouraged by the presence of our blacks, who had almost more to fear from them than we did as they had no more right than us to these foreign lands and they were not protected by the 'Nimbus' of superiority with which the white man faces the black man. We slaughtered a young cow and then they came, all eager to get some. First came a few young women, then old men, and, lastly, a whole group. We let everyone take away a gift. It was not hard to satisfy them, as no part of the animal was scorned. They sat around patiently in a circle on the ground until the distribution began, and at last they went away loaded. A tall black who was 'straight as a candle' provoked great amusement, and we christened him straight away 'Soldier'. He was the last to march off. On his head he carried the cow's skull, and down over his back hung the hide with feet and tail. 'Soldier' now looked even more warrior-like than ever, similar to one of those wild Nordic fighters who decorated their heads in a like manner when the horn decoration was an adornment and an honour to a man.

In return, our black table companions brought us a variety of things: fish, rats, lizards and roots. Not particularly dainty morsels according to European standards, but quite acceptable as a change from the eternal beef menu. Lacking tea, we sampled a type of peppermint that grew along the creek and also tried Nardu seeds as coffee. Both attempts failed, as did the attempt by the smoking members of the party to substitute eucalyptus leaves for tobacco. The imagination of these 'matter of fact' humans was not strong enough to help them overcome the tasteless reality.

I had enough leisure and opportunity to closely observe my new friends. With time they became quite friendly, trusting and forward. As the shyness disappeared through daily contact it was necessary for us to ward them off. Everything which we threw away was, as a rule, taken away by one or the other. Glass and broken glass pieces were much sought after articles. Used to smooth and to point weapons, these were better instruments than the rare quartz pieces that previously served the purpose. Other things would be happily taken away but soon discarded. Clothing had no attraction for these 'nature people', all of whom existed here, in summer and winter, as did our ancestors in paradise. The absence of clothing of every type is explained by the inadequacy of the animal world, which could only provide a few hides. Furthermore, the days are so warm that even in winter, the rainless time, they can get by without protection. The only real clothing or body covering was an apron made from tassels of animal fur worn by the more distinguished men and small handsize aprons made from tightly woven net which some of the women put on at times. The aprons of the men certainly served only to decorate, and were only worn at ceremonies and in fights. They were very precious, requiring much work and effort, and were an heirloom passed on from father to son. Before they were finished, many animals had to be hunted. An 'Unpa' made from tassels of 'Wallaby' fur (Halmaturus), was not as valuable by far, as a 'Thippa' made from over 300 tails of the Belideus (bandicoot), which, in a clean condition, (unfortunately, rarely) looked very beautiful in its snow-white colour. The man who could wear such decorations at the great ceremonies for which the tribes came together or when the warriors went out to fight was indeed a mighty hunter or warrior. Just as highly regarded, perhaps more so, was the string spun from human hair. This was up to 200m. long and rarely seen. Many a human head provided its hair, and the

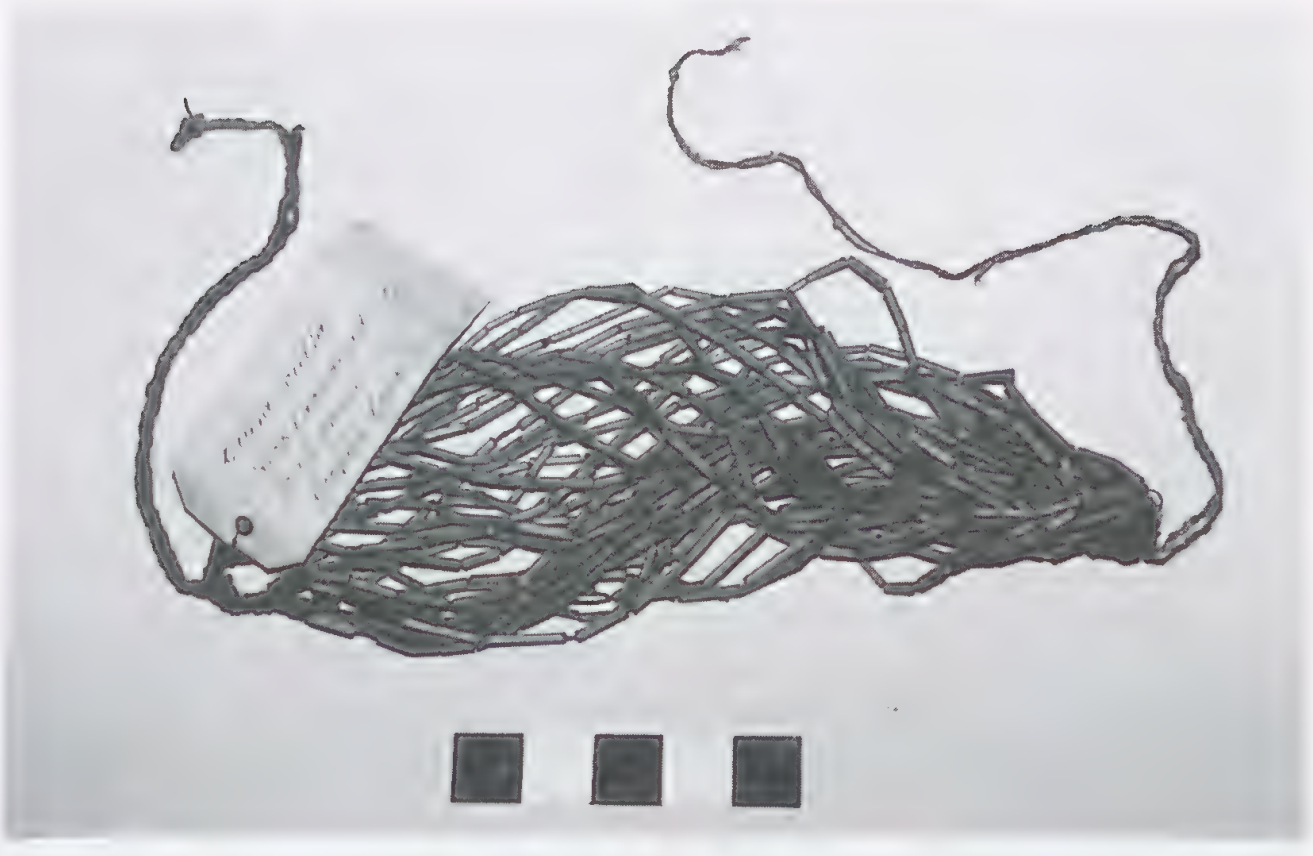

FIGURE 3. Example of a *Cultaculta*, a necklace made of grass stems. Collector unknown, Cooper's Creek. Unregistered, South Australian Museum.

FIGURE 4. Headband made from plant fibres. Collected by J.G. Reuther, Kopperamanna. A3016, South Australian Museum.

hair of the dead is also spun into the 'Yinka' so that it receives a special power. The abilities or skills of those living and the dead who gave their 'head hair', are bound into the girdle and pass into those who wear it, giving them increased power. From the girdle hung the 'Wurtawurta', a bundle made from black emu feathers.

The Aborigines' shaggy hair was held together by the white coloured 'Tschangu', a headband made from plant fibres. The arm was decorated with an 'Unamunda', a string made from the same materials and wound many times around the arm. The old people of importance and influence put on the 'Wurdawurda', the wreath made from emu feathers which they alone deserved. A shell also hung from a band of human hair around the neck or decorated the tips of a not very long yet highly valued beard.

The inhabitants of the Cooper differ from their neighbours in the West, who keep the sides of their faces free from hair by pulling or tearing it out. They also differ from the Northern tribes who remove all facial hair. They allow all that will grow to grow: the full beard for them is a decoration. The head hair is also not touched, however, like the beard, it does not grow very long. In certain ceremonies the hair is shorn very short as a sign of mourning, but as a rule only the women had to undergo the 'tonsure' (the hair clipping). Women have their decorations but, as the role of the women is lower than that of the man, it is considered appropriate that the decoration is less precious and less attractive. The 'Mundamunda', the women's girdle, is spun only out of plant fibres, and the 'Kultrakultra' is made only from pieces of reed which are strung on a string. The women played the same sad role as a slave as everywhere in Australia. They had to put up with every treatment from their tyrant, who in every way had the women at his disposal. They could be killed without any punishment. However, cases also existed in which the relationship was reversed and the master became the obedient servant, and it was the same everywhere in Australia where nobody would help the husband against his shrew.

During a stay of many months I was easily able to study the manners, customs, character and the language of these people. The study was much more interesting than my earlier observations of tribes who had already been, for a longer or shorter time, in contact with the white man and so had lost some of their true and original nature. However, at Coopers Creek it was still a virgin soil on which I stepped well prepared and from which I made a rich harvest.

Understanding them was not hard. The people could understand fairly well the dialect of the Paroo and the Warrego. We were often aided through drawings which they made very skilfully in the sand and soon learnt to make on paper. The flows and breadths of the rivers and creeks, the relative heights of the hills; the distances of fixed points, and the relationship between those points they described with a precision that never let me down during my extensive excursions to the north and north-west. The route of Burke and Wills, which I followed a long way in the direction of the Gulf, I received partly from them, and partly from the envoy of the Munamuckaru tribe of the Daly River who was coincidently present. Their descriptions of the different camping places of Burke as well as McKinlay were exactly correct, and they also characterised the persons by unmistakable mimicry. They were remarkably like children. They liked to look at a thing that was new to them and wanted to touch and possess it. Then, after the attraction of the novelty had worn off, it was thrown away or exchanged for something else. They were easily directed with friendliness and consistency. Alternately, they were easily offended then easily reconciled, soon won over by promises then badly hurt by their being broken, pitying and generous, then quickly vengeful and cruel. So long as they saw us as superior beings whose power was real and to be feared we could meet together with one another. We were never attacked by them due to our vigilance and their fear of our guns (fire weapons), despite them being a hundred fold superior in number. It was probably also due to the beneficial impression and satisfaction they had received in earlier times from the contact with the expeditions of the white man.

We soon found the opportunity to make a wider acquaintance with the whole population of the extensive Cooper district. One day, while still a great drought prevailed, hundreds of visitors arrived from the north and the north-west. They often used this same ceremonial place to call the rain down from heaven and were invited by our neighbours who were the actual rulers of this hunting ground. Women in the company of their 'Pirraru', their 'cavalieri serventi', were sent out to gather the scattered people. We had the opportunity to observe the whole event; the people had no inhibitions about the presence of the strangers or even the white people at this ceremony. The men distanced themselves approximately 500–600 metres from the camp to find an empty site, and dug a depression four metres long, three metres wide and approximately one metre deep. Others dragged heavy wooden logs to build a cone-shaped hut covered by small branches and grass with a low, narrow entrance. Two large stones from the nearby creek were placed in the middle of the hut. The old men took their places inside, while the younger men sat down outside. One of the youngest went to the camp to fetch the women. They came and without speaking a word, looked at the structure, looked inside the hut and then removed themselves. As soon as the women had returned to the camp, the elders called two young, strong people outside and bound the veins of their upper arms. One of the oldest, perhaps the most significant and influ-

ential of them, took a sharp stone and opened the veins. The blood spurted onto the densely gathered group. Those who were bleeding threw handfuls of down feathers from already prepared nets over the others. The feathers stuck onto the wet bodies. The women reappeared to look at the men who now were covered with blood and feathers. The two youths who had been operated on then took the two stones, carried them miles away and hid them in the highest branches of a tree. Those staying behind collected slices of the so-called 'women's ice' that lay in great quantities on the distant mountain range, pounded it, then scattered the powder into the waterholes. One thing remained to be done: the destruction of the hut. The whole group of men stood around in a circle and, with lowered heads, ran towards the hut, smashed the dry branches and appeared on the other side. They then returned to the attack until nothing remained except the heavy wooden logs. These they grasped at one end and pulled them back until the hut collapsed in an unformed heap. Then it was back to the camp to dance. On that night of the full moon, the dancing lasted until the early morning. For the whole night the ground resounded from the heavy stamping of the dancers, and the air reverberated from the monotonous noise of the rhythm which the women beat on their carrying dishes.

A young, intelligent Aboriginal, who had already gone through all stages of initiation, (including the last, most painful and most peculiar rite that was found only in this region), explained that the blood sprayed around signified the rain, the feather down signified the light clouds and the stones signified the heavy pregnant rain clouds. The destruction of the hut symbolised the breaking down and flow from the clouds, and the fall of the hut represented the fall of the rain. That's how I understood him. The good spirit 'Muramura' saw these ceremonies, collected the clouds and the rain poured down. But also perhaps not. The explanation is the same as with all other ceremonies, entreaties or conjuring exercises that failed to achieve an aim or produce a result: an enemy or hostile tribe had spoiled the magic through a contrary incantation. It almost appeared as though the latter was the case. Many weeks passed since that ceremony. The blacks had long since scattered. Our stocks were almost totally consumed, and our isolation became complete when we lost our closest neighbour on the Wilson. Only when Swanhill Jack, my best and most fearless stockman, risked, at increasingly distant intervals, the lonely and distant journey to the next station on the Bulloo, did news of the outside world reach us. Even there one was already almost totally isolated. Old newspapers were now devoured with eagerness, and a new book would have been worth a good cow.

'The longest lane has a turning', says an English proverb meaning that nothing lasts forever. At some time things must change, and so things did change with us on the Cooper. At last the rain came and in the torrents as is usual in Australia. We retired a reasonable distance away to the sandhills or plateau behind us. Soon everything around us was transformed into a surging expanse of water. We were on one island with our horses, cut off from our herd which was scattered in groups here and there, grazing on similar islands. The "blackfellows" had dispersed. The water soon subsided again, but we remained stranded on our island as the black, soggy flats were impassable and the treacherous beds of many small creeks restricted us on all sides. Now we were about to get to know our wild brothers from a different perspective. From the high elevation of our sandhills, we had a panoramic view which included the river flats on both sides. One day we could see that a large hunt was starting on our cattle, who could only move with difficulty in the muddy ground. The greedy hunters sought out the largest animal, and an old well-fed steer fell under their clubs and spears. Soon, however, they had better sense and chose younger animals. Not only did they kill the cattle, but they also cut out the knee joints and sinews, and speared them. They were determined to destroy them by all means. We had to watch this hustle and bustle from a distance. They were no longer scared of the crack of our guns which they saw could not reach them, and answered every shot with scornful shouting. To our consolation they were sometimes introduced to the character of these animals in a most perceptible way when they came too close to the tormented cattle. At last came the day when we could rise up as revengers of the fallen. The earth was dry enough to carry us and our horses.

We prepared ourselves with rifles and revolvers for what would certainly be a hard fight. Although we rode cautiously, our coming was betrayed in advance. As we neared the camp of the blacks, it was a case of 'sauve qui peut' or 'everyone for themselves'. The men, who were totally unconcerned about the women and children, ran in great haste over the flat to the creek, threw themselves into it, swam across and disappeared behind the sandhills lying there. The women, loaded up with children and all kinds of possessions, were soon rounded up. I believe the poor creatures thought their last hour had come. I had as little reason to vouch for the security of the men had we caught them as I had to believe that one of my people would raise a hand against a woman. We indicated to them to turn back. Trembling and quietly lamenting, they marched back to camp. There I ordered them to pull together a heap of brushwood and to lay all their belongings (which were not many) on top of it. A few weapons which, in the haste, were left behind, I kept for myself. The remaining things – carrying dishes; greasy nets; girdles; skin aprons and coats; and, 'last but not least', the small knitted net bags with magic bones and red ochre were all put on

the pyre. Without hesitation or resistance the people obeyed my commands, then stood silently around. The flames snaked upwards and reached their miserable possessions. Then, as if they thought that the burning of these magic instruments must bring about the death of relations, spouses, and children, there rose a wailing and moaning that certainly reached their menfolk – their 'protectors' – who were secure some distance away. They probably thought that their wives and offspring whom they had so cowardly abandoned were being killed by our guns and knives. But the eyes of our blacks were fixed with concentrated attention on the glowing mass. Before we knew what was happening, eager hands, careless of burns, reached into the fire in order to save the amulets from the fiery oven. What were these pains and wounding compared to the certain death which was being prepared for them and others? Nevertheless, justice had to be done, and I stayed until those amulets were turned to ashes. Then we turned our horses and left the place. I was curious and also worried about what would follow that 'auto da fe' (punishment by burning) for the inhabitants. Although I made many enquiries, I could never determine whether any person had sometime later suffered a misfortune in connection with that event. I can well say that I was relieved over that. In retrospect, I could see that the behaviour of the Aborigines was justified. What they had done was based on their concept of what they must do as their right and duty. They wanted to show the foreign intruders who wished to use their hunting ground for grazing ground that his cattle could not live where their hunting animals must live and where they themselves should live. They used legitimate means. They submitted themselves as long as they had to, then made use of the favourable opportunities as they came. What could be more right and understandable?

A few weeks later I turned my back on the Cooper, the bush and the wilderness forever, and drove my herd down the Strzelecki. The floods had not arrived there. There was scarce water at only a few places. The worst that happened was when we crossed salt lakes on the downward run. These lakes were tempting for the thirsty animals but dangerous. I had solved by that expedition an important problem for the settlement of Australia, and proved that even in drought years it is possible to transport cattle over long distances of desert and pastureless tracks to the capital city of South Australia. This changed the squatters' thinking on pasture and acquisition, enabling practices which have already for some years become a profitable reality.

Acknowledgments

The author thanks Quentin Lynn for his assistance in editing this paper and Connie Fröhlich for her assistance with the German translation.

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A NEW GENUS OF MARSUPIATE SPATANGOID ECHINOID FROM THE MIOCENE OF SOUTH AUSTRALIA

K. J. MCNAMARA & D. J. BARRIE

MCNAMARA, K. J. & BARRIE, D. J., 1992. A new genus of marsupiate spatangoid echinoid from the Miocene of South Australia. *Rec. S. Aust. Mus.* 26(2): 139–147.

The southern Australian Tertiary fossil record contains a relatively rich fauna of marsupiate echinoids. The 10 species currently known are placed in five genera, and are supplemented by this description of a new genus and species of marsupiate spatangoid echinoid, *Hysteraster paragrapsimus* gen. et sp. nov. Collected from the late Early Miocene to early Middle Miocene Morgan Limestone on the banks of the Murray River, South Australia, this new form is characterised by the possession in the female of deeply sunken apical system and petals on the aboral surface. The male of this genus can be distinguished from the female by its much smaller gonopores and lack of sunken petals. The genus is placed in the family Brissidae and, as such, is the first record of a marsupiate genus in this family.

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Manuscript received 7 April 1992.

The Tertiary rocks of southern Australia contain one of the richest echinoid faunas of this age in the world, with some 60 genera having been described (McNamara in prep.). A characteristic feature of this fauna is the presence of marsupiate echinoids - those echinoids that bear depressions in their test that were used for brooding the young. To date some 10 marsupiate species have been described from the Tertiary rocks of southern Australia, all by Philip & Foster (1971). At the time of their publication only one other Tertiary marsupiate echinoid was known from elsewhere in the world: *Abatus pseudoviviparus* (Lambert), from the Paleocene of Madagascar. However, since then Roman (1983) has described a further four species from the Middle Miocene and Pliocene of western Europe. Of this total of 15 Tertiary species, only three are spatangoids: *Abatus pseudoviviparus*, and the two species of *Peraspatangus* that Philip & Foster (1971) described from Australia, *P. brevis*, from the Early Miocene, and *P. depressus* from the Middle Miocene.

The discovery of two specimens by one of us (J. B.) of a hitherto undescribed spatangoid genus from the late Early to early Middle Miocene Morgan Limestone downstream of Waikerie on the banks of the Murray River, therefore brings to three the number of marsupiate genera of spatangoid echinoids now known from the Tertiary. A single specimen in the collections of the Museum of Victoria is also referred to this genus, as is a specimen from Wigley Reach, near Overland Corner on the Murray River in the collections of the South Australian Museum. Although lacking the sunken petals and apical system characteristic of the females, the other test characters appear to be sufficiently similar to indicate that this lone specimen is the male of the species.

Stratigraphy

The Morgan Limestone, from which the type specimens were collected, outcrops along the bank of the Murray River in the vicinity of Morgan. In its type section, six kilometres south of Morgan, the unit reaches a thickness of about 30 m (Ludbrook 1961). In some parts of the Murray Basin it is up to 100 m thick (Ludbrook 1969). The Morgan Limestone straddles the Early to Middle Miocene boundary in age (Australian stages Batesfordian to Balcombian, Lindsay 1985). The dominant echinoid is a clypeasteroid, *Monostychia* sp. Other echinoids collected from this unit include *Phyllacanthus clarkii* (Chapman & Cudmore) (Philip 1963); *Goniocidaris murrayensis* Chapman & Cudmore (Philip 1964); *G.? pentaspinosa* Chapman & Cudmore (Philip 1964); *Delocidaris prunispinosa* (Chapman & Cudmore) (Philip 1964); *Menocidaris compta* Philip 1964; *Murravechinus paucituberculatus* (Gregory) (Philip 1965); *Cryptechinus humilior* (Bittner) (Philip 1969); *Orthologhus morganensis* Philip 1969; *O. pulchellus* (Bittner) (Philip 1969); *Schizaster (Schizaster) abductus* Tate (McNamara & Philip 1980); *Pericosmus compressus* (Duncan) (McNamara & Philip 1984); *Protenaster antiaustralis* (Tate) (McNamara 1985); *Cyclaster archeri* (Tenison Woods) (McNamara *et al.* 1986); *Eupatagus rotundus* Duncan (Kruse & Philip 1985); and *E. ludbrookae* Kruse & Philip 1985.

Material and Methods

The material described in this paper is deposited in the collections of the South Australian Musuem (SAM) and the Museum of Victoria (MV). Measurements

were carried out using electronic callipers to a precision of ±0.1 mm. Relative sizes of features of the test are expressed as percentages of maximum test length (%TL).

Systematic Palaeontology

Order Spatangoida Claus, 1876

Family BRISSIDAE Gray, 1855

Genus *Hysteraster* gen. nov.

Etymology

From the Greek *hystera*, meaning 'womb', and *aster*, meaning "star", alluding to the formation of the marsupium from the star-shaped petals.

Diagnosis

Test moderately large, relatively narrow and with slight anterior notch. Apical system set well anterior of centre; deeply depressed in females. Petals short, broad and deeply depressed in females, only slightly depressed in males; do not extend to peripetalous fasciole; pore pairs very reduced in size in anterior rows of anterior petals; in all petals pore pairs absent in vicinity of apical system. Apical system ethmolytic with four gonopores. Peripetalous and subanal fascioles present. Aboral tubercles much larger within peripetalous fasciole than outside of it; those in interambulacra 2b and 3a are the largest and most sparsely distributed. Peristome subcentral. Plastron small, with prominent posterior keel. Periplastronal area wide.

Remarks

There seems little doubt that the deeply sunken petals in *Hysteraster*, combined with a deeply sunken apical system, functioned as a marsupium. This is supported by the presence of large gonopores in the female (see below). *Hysteraster* can be distinguished from all other marsupiate spatangoids by its possession in the female of both deeply sunken apical system and deeply sunken petals. In the living spatangoids *Abatus* and *Tripylus*, which also have deeply sunken petals, the apical system is not depressed at all. The only spatangoid to share the combination of sunken aboral ambulacra and apical system is the Australian Tertiary genus *Peraspatangus*. However, in this genus just a simple depression is formed, comprising the apical system, the adapical ambulacra and interambulacra, whereas in *Hysteraster* the adapical interambulacra are not sunken. Unlike *Peraspatangus*, with its non-petaloid adapical ambulacra, pore pairs are present in the marsupium in *Hysteraster*, although they do degenerate in the vicinity of the apical system and in the anterior rows of the anterior petals.

One of the specimens, SAM P24260 (Fig. 2) shows the presence of a well developed subanal fasciole. Consequently it is possible to place *Hysteraster* within the Brissidae with confidence as a peripetalous fasciole is also present. Furthermore, the overall appearence of the test, the presence of a prominent plastronal keel, a feature usually present in those genera possessing a subanal fasciole, and the development of larger tubercles within the peripetalous fasciole, support the emplacement of *Hysteraster* within the Brissidae. This is the first record of a marsupiate genus within this family. Although a few other brissid genera, such as *Rhynobrissus*, *Macropneustes*, *Meoma* and *Schizobrissus* have sunken petals, they are much shallower than in *Hysteraster*, and there is no evidence that such forms were marsupiate.

The male *Hysteraster* can be distinguished from other brissids by the nature of its relatively short, broad, slightly sunken petals; its very anteriorly situated apical system; degenerate pore pairs in the anterior row of the anterior petals and distinctive aboral tuberculation. The only other genera that possess some of these characters are *Migliorina* and *Plesiopatagus*. However, *Hysteraster* differs from the former in possessing larger tubercles inside the peripetalous fasciole, and from the latter in its possession of four, rather than two, gonopores. Furthermore, neither of these two genera is known to be marsupiate.

One of the characteristic features of *Hysteraster* is the failure of the anterior paired petals to reach the peripetalous fasciole (Fig. 4). There are few other spatangoids which share this attribute, but one is the living marsupiate *Tripylus*. However, in the other living marsupiate spatangoid, *Abatus*, the anterior petals do reach the fasciole. An unusual feature of *Hysteraster* is the presence of the enlarged primary tubercles, not only on the interambulacra within the peripetalous fasciole, but also in ambulacra II and IV between the ends of the petals and the fasciole. Selective pressure for the presence of primary tubercles must have been particularly strong.

Hysteraster paragrapsimus sp. nov.
(Figs 1–4)

Etymology

From the Greek '*paragrapsimos*', meaning 'exceptional', in reference to the extent of development of the marsupium.

Material

Holotype: SAM P32322, from the late Early to early Middle Miocene Morgan Limestone, Murray River cliffs, downstream from Waikerie at Broken Cliffs, South Australia.

Paratypes: SAM P32323 from the same horizon and locality as the holotype; SAM P24260, probably

FIGURE 1. *Hysteraster paragrapsimus* gen. et sp. nov. SAM P32322, holotype, ♀, from near Waikerie at Broken Cliffs, Murray River, South Australia; Morgan Limestone; A and B stereopair of aboral surface; C, adoral surface; D, lateral view; all x1.3.

from the same horizon at Wigley Reach, near Overland Corner, Murray River cliffs; and MV 18039, probably from the Morgan Limestone near Morgan, South Australia. Mr F. Holmes (pers. comm.) informs us that no locality details are entered for this specimen in the catalogues of the Museum of Victoria. However, it is registered with a suite of specimens that was collected by F. A. Cudmore form the Morgan Limestone in the vicinity of Morgan.

Diagnosis

As for the genus.

Description

Test moderately large, reaching up to 54 mm TL in females; male has test length of 30.5 mm; ovate, with a very faint, broad anterior notch in some specimens and broadly rounded ambitus; highest posteriorly in interambulacrum 5, midway between apical system and posterior ambitus; height 50–55%TL in females, 55%TL in male; test longer than wide, width ranging between 84–88%TL in females and 83%TL in male; widest posterior of centre. Aboral surface plunges steeply anteriorly (Figs 1D, 2E). Apical system anteriorly eccentric, 27–30%TL from anterior

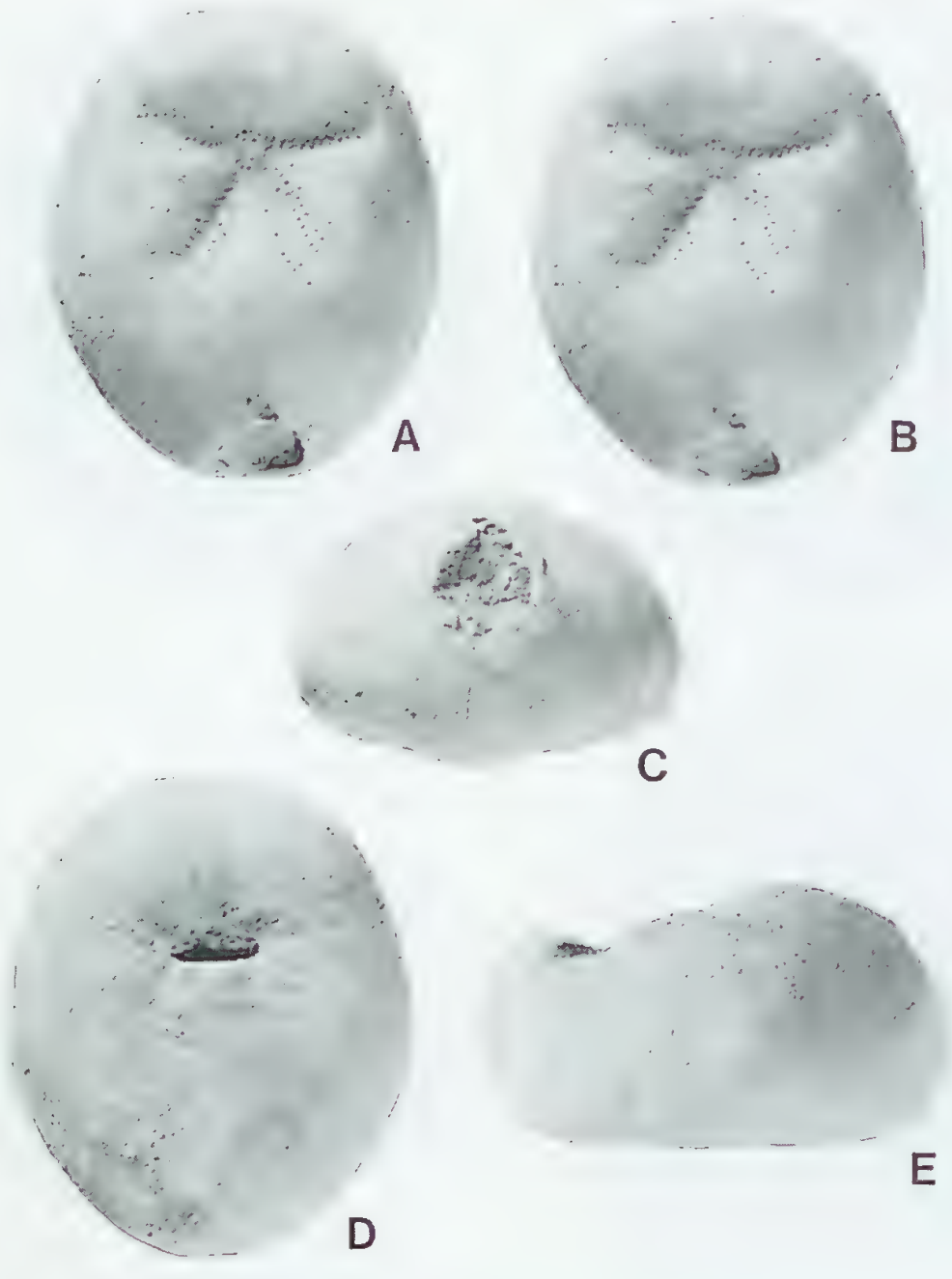

FIGURE 2. *Hysteraster paragrapsimus* gen. et sp. nov. SAMP24260, paratype, ♀, from Wigley Reach, near Overland Corner, Murray River, South Australia; Morgan Formation; A and B, stereopair of aboral surface; C, posterior view; D, adoral surface; E, lateral view; all x1.3.

ambitus in females, 32%TL in male and extremely deeply sunken in marsupium in females, up to 56%TH from apex of test in paratype female; only slightly sunken in male; ethmolytic, with four gonopores; very large in females (Fig. 1A,B); very small in male, one-seventh the female width; anterior pair in female circular, in holotype 1.3%TL in diameter; posterior pair pear-shaped, long axis 2%TL; madreporite extends slightly beyond posterior gonopores (Fig. 4).

Ambulacrum III narrow and not sunken close to apical system, becomes a little wider and very slightly sunken as crosses anterior ambitus; pore pairs extremely small; number not known. Petals relatively short, broad, although narrowing distally, and open distally; distal one-third not sunken; proximal two-thirds deeply sunken in females, plunging to deeply sunken apical system (Figs 1A,B; 2A,B; 3A,B; 5); slightly sunken in male (Fig. 3G). Anterior petals straight, broad, width 8–9%TL; diverge anteriorly at about 150°; short, 18–19%TL; bear up to 12 pore pairs within petals, those in ambulacra IIb and IVa very reduced in size (Fig. 4), about one-third size of those in IIa and IVb; pore pairs degenerate at about one-quarter petal length from apical system in poste-

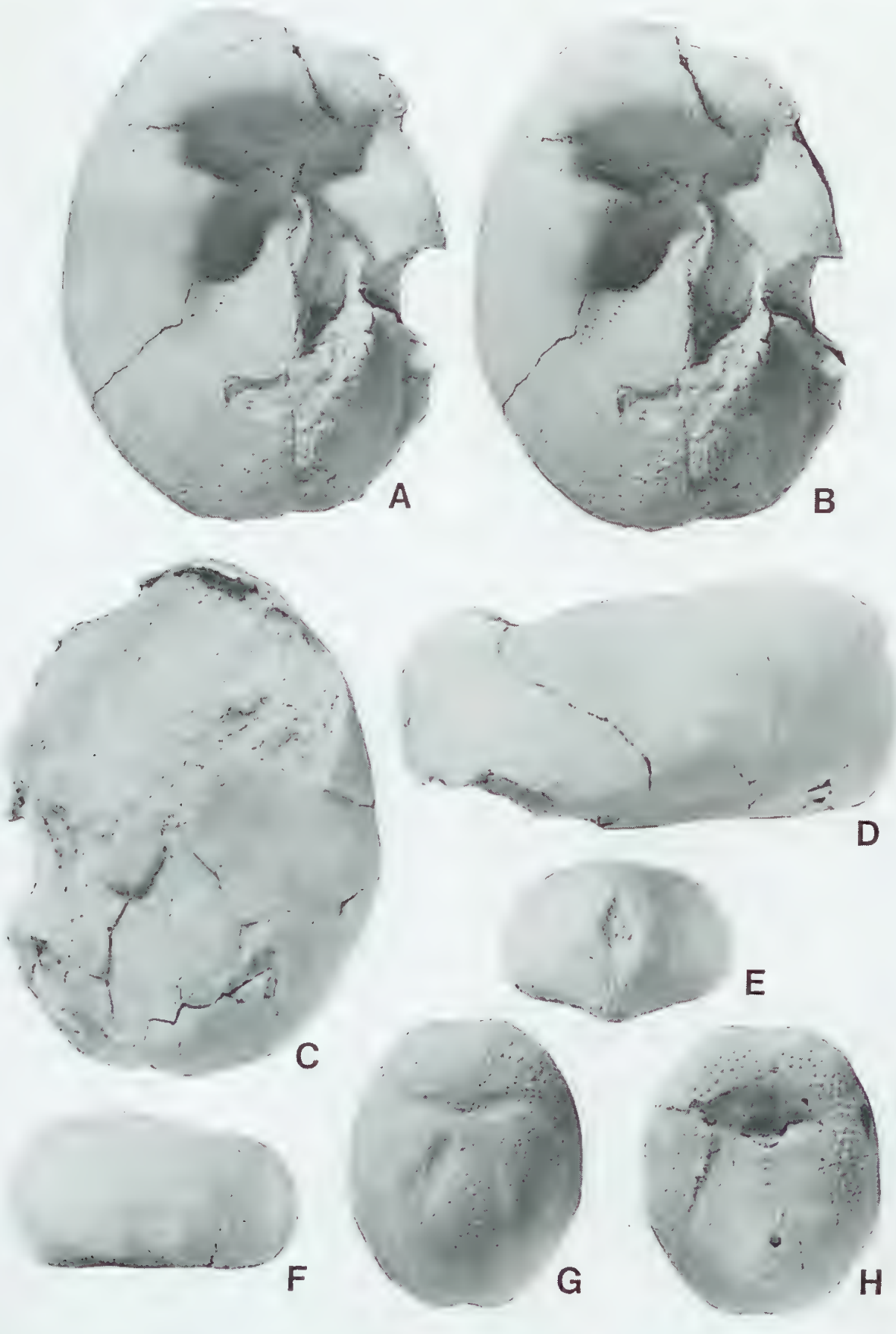

FIGURE 3. *Hysteraster paragrapsimus* gen. et sp. nov. A-D, SAM P32323, paratype, ♀, from near Waikerie at Broken Cliffs, Murray River, South Australia; Morgan Limestone; A and B, stereopair of aboral surface; C, adoral surface; D, lateral view. E-H, MV P18039, paratype, ♂, probably from the Morgan Limestone near Morgan, South Australia; E, posterior view; F, lateral view; G, aboral surface; H, adoral surface; all x1.3.

rior row; pores slightly elongate proximally, becoming circular distally, not conjugate. Posterior petals longer than anterior, being 31–35%TL; bear up to 17 pore pairs; pores in each poriferous tract of similar size; reduced adapically; slightly broader than anterior petals, being 10–11%TL; petals diverge posteriorly at about 50°.

Peripetalous fasciole quite narrow, about 1.5%TL in width; not indented between anterior and posterior petals; runs along the ambitus anteriorly, and close to the ambitus opposite anterior petals; both anterior and posterior petals fail to reach the fasciole (Fig. 4). Subanal fasciole subtends a chevron shape outline (Fig. 2C) that is 35%TL in width; fasciole twice width of peripetalous fasciole.

Aboral tubercles very variable in size; outside of the peripetalous fasciole towards the ambitus very densely distributed and small, up to a diameter of 0.3 mm; within the peripetalous fasciole in interambulacra 1, 4, 2a, 3b and 5 tubercles larger and more sparsely distributed, up to a diameter of 0.9 mm; these are also present in ambulacra II and IV between ends of petals and peripetalous fasciole; in interambulacra 2b and 3a they are larger still adapically (Fig. 1A,B) and even more sparsely distributed, with up to eight crenulate tubercles that reach 1.25 mm in diameter.

Adoral surface gently convex. Peristome slightly sunken; width 15–18%TL; anterior situated 28–32%TL from anterior ambitus (Fig. 2D). Phyllode comprises 6 small unipores in ambulacra I, II, IV and V; 3 in ambulacrum III. Labrum short, 5%TL; not projecting anteriorly across peristome. Plastron narrow, length 40%TL; width 25–28%TL; almost flat, but forming a prominent keel posteriorly (Fig. 3E). Periplastronal area wide (Figs 1C; 2D; 3C,H), up to 17%TL. Periproct oval, long axis vertical (Fig. 3E), 15%TL. Adoral tuberculation relatively sparse, but becoming more dense adambitally; tubercles up to 0.8 mm in diameter.

Discussion

Most of the slight differences that are observed between the three female specimens and the sole male probably relate to the size difference between the females and the male, the latter being only slightly more than half the size of the former. These differences include relative test height, test width and position of the apical system. Whether or not the size difference itself is a sexually dimorphic feature is not clear. While a greater range of specimens would be required before this could be ascertained, Kier (1969) and Smith (1984) have noted that female echinoids are often larger than males.

In addition to the obvious reflection of the sexual dimorphism, namely the presence of the marsupium of the female and its absence in the male, the difference in gonopore size between the females and the male is another sexually dimorphic feature. Such dimorphism has been documented in some echinoid species by a number of authors, *e.g.*, in *Pentedium* by Kier (1967), in *Echinocyamus* and *Oligopygus* by Kier (1969), in *Echinocardium* by David *et al.* (1988) and in *Hemiaster* by Jagt & Michels (1990); see also Emlet (1989). However, whereas the difference in gonopore diameter in these non-marsupiate forms never differs by more than a factor of two, in *Hysteraster*, and in the other Australian Tertiary marsupiate spatangoid *Peraspatangus*, it is much greater, presumably to accomodate the larger eggs produced by these brooding species.

Wray & Raff (1991) have noted how echinoids that produce the largest eggs are brooding species, egg size ranging between 1 and 2 mm in diameter. Emlet (1989) has observed that marsupiate echinoids in general have particularly large gonopores, relative to their body size, presumably to accommodate the large eggs. The gonopores of female *H. paragrapsimus* reach up to 1.2 mm in diameter. In *Peraspatangus brevis* Philip & Foster, 1971 the female gonopores are nearly four times the diameter of the male gonopores (Philip & Foster 1971, pl.133, fig. 4). In *Hysteraster paragrapsimus* it is even greater, the gonopores in the larger female (Fig. 1A,B) being about seven times the diameter of those of the male. However, this is in part a function of the differences in test size between the male and female forms. Emlet (1989) has noted that there is a positive relationship between increasing test size and increasing gonopore size. For instance he has shown how in males of the living marsupiate echinoid *Amphineustes lorioli* there is an approximate doubling in size of the gonopores as the test length doubles. In females the allometric coefficient is even greater (see Emlet 1989, figure 3). In *Hysteraster paragrapsimus* the extent of increase in females is likely to be as great.

Although *Hysteraster paragrapsimus* and the two species of *Peraspatangus* are the only spatangoids that possess a marsupium that is constructed from a combination of sunken petals *and* apical system, there is one feature in which the two genera differ from one another. In *Peraspatangus* the ambulacra in the marsupium do not possess any pore pairs. While they are present in the marsupium in *Hysteraster* they are very much reduced in the vicinity of the apical system and in the anterior rows of the anterior petals (see Fig. 4).

There is some difference in the degree of development of the marsupium in the female specimens of *Hysteraster paragrapsimus*. In the paratype SAM P32323 the marsupium attains a depth that is nearly twice that of the marsupium of the holotype. However, as the two specimens are virtually identical in all other respects, it is considered that this difference merely reflects intraspecific variation. The smaller female specimen (SAM P24260) has a marsupium

FIGURE 4. Drawing of pore pairs in petals of *Hysteraster paragrapsimus* gen. et sp. nov., holotype, ♀, SAM P32322. Note reduction in size of pore pairs adapically; large gonopores; and failure of pore pairs to reach the peripetalous fasciole.

that is similar in depth to that of the holotype, but the adapical interambulacra surrounding the marsupium are more swollen in this smaller specimen, so enhancing the effective depth of the marsupium.

Functional morphology of *Hysteraster*

Certain characteristics of the test indicate that *Hysteraster* shares the distinction, along with the living spatangoids *Abatus* and *Tripylus*, of being the only echinoderms known to brood their young while buried in the sediment. The existence of a well developed peripetalous fasciole, combined with the wedged shape profile of the test indicate that *Hysteraster* lived completely buried in the sediment. Peripetalous fascioles are a prerequisite for spatangoids that completely burrow in the sediment, while McKinney (1988) has observed that a wedged shape test is often found in spatangoids that burrow in relatively fine-grained sediments, such as those in which *Hysteraster* are preserved. Other brissids that, like *Hysteraster*, possess larger primary spines on the aboral surface are interpreted as being shallow burrowers, with their aboral surface just covered by sediment (McNamara 1991). Further evidence that these genera brooded their young while buried in the sediment is afforded by the preservation of tiny juveniles in the petals of two specimens of the Paleocene species *Abatus pseudoviviparus* (see Lambert 1933, pl. 4, figs 5–7). Such preservation could only occur if there was no disturbance to the specimen after its death, such as would have been the situation with a specimen completely buried by sediment – it was 'preadapted' to being fossilised.

In the case of these burrowing marsupiate spatangoids, following their 'birth' the young echinoids would have nestled in the deep marsupium on the aboral surface of the test (Fig. 5). This method of brooding could have provided the young with exceptional protection from predators for a number of reasons. In addition to the presence of the deep marsupium, the tent of mucus that the peripetalous fasciole would have throw over the marsupium would also have protected the young echinoids. Furthermore, the larger spines that arched over the petals from interambulacra 2 and 3 would have provided a protective advantage. Orientation of the prominently

crenulate tubercles provides evidence that the spines would not have extended perpendicular to the test, but at a very low angle, almost tangential, to the surface of the test across the petals. Finally, the young echinoids would also have been protected from predators by the sediment that would have covered the entire aboral surface of the test.

The absence of pore pairs in the vicinity of the apical system in *Hysteraster paragrapsimus* and reduction in size of the pore pairs in the anterior row of the anterior petals, combined with the absence of pore pairs in the marsupium in the two species of *Peraspatangus*, suggest that their reduction may be related to the presence of brooded juveniles in the marsupium. Brooding in ambulacral marsupia can only be effective if tube feet are reduced in size to allow sufficient space in the petals to accomodate the juveniles. If this is the case then it is likely that the brooded juveniles were concentrated in the area immediately surrounding the apical system, along the anterior part of the anterior petals, and perhaps in the central part of the posterior petals, between the pore pairs. It is worth considering whether the presence of reduced pore pairs in the anterior row of the anterior paired petals in other spatangoids, such as *Atelospatangus, Paramaretia, Nacospatangus* and *Agassizia,* is indicative of these echinoids also being brooders.

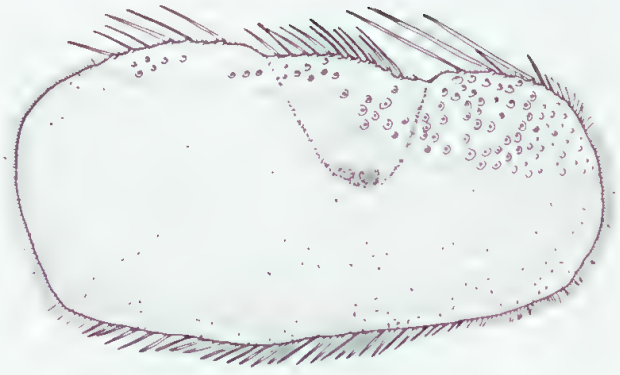

FIGURE 5. Restored profile of *Hysteraster paragrapsimus* gen. et sp. nov. ♀, showing course of peripetalous fasciole, distribution of primary tubercles and extent of maximum known development of marsupium. Spine orientation based on data from tubercles; spine length conjectural.

ACKNOWLEDGMENTS

We would like to thank Neville Pledge of the South Australian Museum for the loan of specimens, Frank Holmes for his help with information and Kris Brimmell for photography.

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NOTES ON FRECKLED DUCK *STICTONETTA NAEVOSA* SHOT AT BOOL LAGOON, SOUTH AUSTRALIA, 1980

F. I. NORMAN & P. HORTON

NORMAN, F. I. & HORTON, P. 1993. Notes on freckled duck *Stictonetta naevosa* shot at Bool Lagoon, South Australia, 1980. *Rec. S. Aust. Mus.* 26(2): 149–152.

Freckled ducks *Stictonetta naevosa* (n = 164) were collected at Bool Lagoon, South Australia, following the opening of the 1980 waterfowl season. Birds were generally sexed and aged, and routine body measurements taken. Wherever possible, the identity of foods, and ectoparasites and endoparasites, was established, and moult and reproductive details were obtained from subsamples. Most ducks were adult; body masses were not low and many birds had extensive fat deposits. In this sample, the birds showed no reproductive activity but maintained body weight and fat reserves, apparently by eating a range of plant and animal foods. Counts and surveys of hunters' activities suggest that Bool Lagoon is a refuge for birds which disperse from normal breeding areas in times of drought.

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The freckled duck *Stictonetta naevosa* is generally distributed in southern Australia, particularly in the south-east and south-west. In South Australia the species is relatively rare, being found primarily in the Murray Valley, Bulloo and Lake Eyre basins, but showing occasional peaks of abundance in other areas (Parker *et al.* 1985, Marchant & Higgins 1990). Indeed, much of the population in eastern Australia may originate from the Lake Eyre basin itself (Parker *et al.* 1985). At times, numbers increase dramatically on some more southern wetlands which are used as refuges rather than breeding habitat. When such concentrations coincide with the annual open season on waterfowl, in South Australia as elsewhere in south-eastern Australia, freckled duck become an illegal part of the harvest. Relatively large numbers of freckled duck have been killed during the earlier parts of some open seasons (*e.g.* in Victoria, Corrick 1980, Corrick 1982, Norman & Norris 1982; in South Australia, Reid 1980), creating concern for the population of this poorly understood species.

Bool Lagoon, South Australia, a state game reserve of 2 690 ha, has *ca* 2 400 ha of open water when full (the adjacent Hacks Lagoon Conservation Park holds some 130 ha of additional wetland). On the opening day of the 1980 waterfowl season (1 March), there were up to 5 000 freckled duck present in the area (Parker *et al.* 1985). This note provides a summary of measurements and details of reproductive activity, parasites and diet obtained from 164 freckled duck carcasses collected at Bool Lagoon on the opening day. When collections were made, *Triglochin procera* was growing through most of the open water and freckled ducks were mainly in or around a large stand of *Melaleuca halmaturorum*, itself inundated by water.

Methods

Carcasses of freckled duck (164) were collected in and around Bool Lagoon on 1 March 1980, either from hunters directly or from the water where they had been left. The birds were dried and frozen until later examination and or preparation as study skins (132). Once thawed, sexes and 'ages' were determined for most birds using gonad examination and the presence or absence of juvenile tail feathers. Many birds (119) were weighed (to 1g), and total body length and wing span (to 1mm, carcass relaxed and extended), wing chord length (to 1mm, gently flattened), length of central tail feathers and tarsus, bill length (feathers to tip) and bill width (at nares) (all to 0.1mm) obtained. Some birds (56) were also examined for the presence of moult in primary and secondary tracts, as well as tail and body tracts generally (here moult was considered as absent, 1; slight – moderate, 2; heavy, 3); wear of primary feathers was also scored (1 – 4, following Braithwaite & Norman 1974). Gonads from a sample of the freckled ducks (92) were drawn to scale; testes lengths were determined from the scale drawings (to 0.5mm), and follicle size in ovaries classified as developed (>3 mm) or not (see Norman & Norris 1982). Oviducts were classified as straight or convoluted. Fat deposits (subcutaneous, peritoneal, anal or thoracic) were considered collectively and assigned to a category (0 = none, 4 = heavy), and the extent of skull ossification was also determined in 58 birds. Body masses, total lengths and wing spans of most birds were obtained within six months of collection, but some freckled ducks were not weighed and measured until 15 – 24 months later. This later sample was used to identify mensural changes under storage conditions.

Ectoparasites were collected from some carcasses by brushing. Food material was removed from 39 gizzards (few birds had complete food items in oesophagi), separated into recognisable taxa and submitted, preserved, for identification. Obvious endoparasites were also collected and preserved, and later identified.

In statistical comparisons below, p values of 0.05 have been accepted as significant unless otherwise indicated and variances examined for equality.

Results

General

Of the 140 freckled duck aged, 128 (91.4%) were considered adult and 12 (8.6%) immature. Of the 146 birds sexed, 93 (63.7 %) were males, a significant departure from unity ($X^2 = 10.959$, df 1, $p < 0.001$) and one more obvious in the adults examined, where 77 (68.7 %) of 112 were males ($X^2 = 15.750$, df 1, $p << 0.001$). However, only two of the 10 birds considered immature were males. Skull ossification was complete in the 58 birds examined and fat deposits (assessed in 89 birds) were usually extensive (54 birds, 60.7 %); there were no birds without fat present (Table 1). There was no significant difference in the extent of fat assessed between adult males or females (Wilcoxon rank sum test).

TABLE 1. Fat deposits in freckled duck examined from Bool Lagoon, South Australia, 1 March 1980. (1 = slight, 4 = heavy; a = includes unaged and or unsexed birds).

		Category of deposit				
		1	2	3	4	Total
Sex/age						
Male	– adult	15	2	9	23	49
	– immature					0
Female	– adult	9	2	3	8	22
	– immature			2	3	5
All birds[a]		31	4	16	38	89

Measurements and body mass details for adult male and female freckled duck are summarised in Table 2, as are data from all birds examined. Adult male birds had significantly longer wings than adult females ($t = 6.601$, df 94, $p < 0.0001$), were longer ($t = 8.9297$, df 39.4, $p < 0.0001$) and had a greater wingspan ($t = 3.2377$, df 100, $p < 0.001$). The males were also heavier than females ($t = 9.7091$, df 93, $p = 0.0001$), had longer ($t = 9.5095$, df 92, $p < 0.0001$) and wider ($t = 4.2004$, df 94, $p = 0.0001$) bills, and longer tarsi ($t = 2.7128$, df 93, $p = 0.0080$). Tail lengths, however, were not significantly different. In neither males nor females were bill widths well correlated with bill lengths. Samples of immature males were insufficient for comparison with adults; however, immature females were shorter ($t = 2.3253$, df 22.4, $p = 0.0295$) than adults. Of the 33 adult female oviducts examined, 30 were convoluted and one slightly convoluted; seven of the eight females considered immature had straight oviducts. None of the 49 ovaries included enlarged follicles. Right testes lengths averaged 7.89 ± s.d. 1.95 mm (n = 43) and the mean left testis length was 10.18 ± 2.22 mm (n = 42). In adult males, respective lengths were 8.11 ± 1.95 (n = 33) and 10.61 ± 2.00 (n = 32) mm.

For adult males, body masses of those weighed late (mean 1 049.1 ± 57.4, n = 15), were similar to those of birds weighed nearer the time of collection (1 059.4 ± 81.7, 51), and wing spans also showed no significant difference (t-tests) between the two groups. However, mean total body length was significantly higher ($t = 3.0651$, df 66, $p = 0.0022$) in those adult males measured earlier (575.1 ± 15.6, n = 54) rather than later (561.2 ± 15.6, n = 14). In adult females, there were no such differences.

Wing wear for the 56 birds examined is summarised in Table 3. Few birds of any age or sex group had heavily worn primaries and, of the 49 adults examined, 34 (69.4 %) had wings showing slight to moderate wear. None of the ducks (58) had primary or secondary feathers in moult (absent or growing), only

TABLE 2. Measurements and body mass details (mean ± s.d., range, sample size) for freckled duck collected at Bool Lagoon, South Australia, 1 March 1980. (a = includes unaged and/or unsexed birds).

	Adult male	Adult female	All birds[a]
Body mass (g)	1057.0 (76.55; 900-1230; 66)	889.6 (79.4; 722-1064; 29)	989.9 (119.4; 570-1230; 119)
Wing length (mm)	228.3 (6.6; 209-242; 65)	219.2 (5.3; 206-232; 31)	225.9 (7.8; 206-243; 138)
Total length (mm)	572.2 (16.0; 530-610; 68)	524.3 (27.8; 420-600; 31)	552.9 (32.1; 420-610; 131)
Wingspan (mm)	803.9 (33.4; 715-866; 70)	781.8 (28.6; 730-840; 32)	793.7 (35.8; 670-866; 133)
Tarsus (mm)	44.4 (2.5; 38.0-48.0; 65)	43.0 (2.2; 37.2-46.7; 30)	43.8 (2.5; 37.0-48.9; 142)
Bill length (mm)	56.1 (2.2; 46.2-61.0; 64)	51.6 (2.0; 48.0-56.9; 30)	54.5 (3.1; 46.2-61.0; 141)
Bill width (mm)	16.3 (1.1; 11.8-17.9; 65)	15.4 (0.6; 13.9-17.2; 31)	16.2 (1.1; 11.8-20.5; 143)
Tail length (mm)	68.5 (2.5; 63.2-77.6; 50)	67.6 (2.3; 64.2-73.2; 27)	68.0 (2.4; 63.2-77.6; 103)

eight (of 58) birds had any tail moult but 55 of 60 birds examined for body tract moult showed slight to heavy amounts of replacement underway.

Foods

Food material was sorted into major taxa. Small molluscs (Planorbidae: *Glyptophysa* (= *Physastra*), *Amerianna*, *Segmentina*, *Gyraulus* and *Isidorella* spp.; Hydrobiidae: *Fluvidona* sp.; Viviparidae: *Notopala* sp.; Lymnaeidae: *Lymnaea* sp.; the sphaeriid bivalve *Sphaerium tasmanicum*), insects and larvae, ostracods (including *Candonocypris novazealandae*), amphipods and cladocerans were present in most samples, which also included *Chara* sporocarps, seeds of *Chenopodium* spp., *Sarcocornia quinqueflora* and seeds of composites, graminids and angiosperms.

Parasites

Feather lice, the amblycercan *Trinoton querquedulae* (commonly found on waterfowl) and the ischnoceran *Acidoproctus moschatae* (previously recorded only from the red-crested pochard *Netta rufina*, R. Palma, pers. comm., although *Acidoproctus* sp. has been collected from *Stictonetta* examined in Victoria, Van Mourik & Norman 1985), were found on some birds, and the trematode *Echinoparyphium* sp. in others.

TABLE 3. Wing wear in freckled ducks collected at Bool Lagoon, South Australia, 1 March 1980.

	Wing wear category				
	1	2	3	4	Total
Age/sex group					
Adult male	7	10	4	3	24
Immature male	1	1			2
Adult female	2	2	4	1	9
Immature female	1		1	1	3
Unaged/unsexed	2	8	7	1	18
Adults	10	20	14	5	49
Immatures	3	1	1	1	6
All birds	13	21	16	6	56

Discussion

Freckled duck shot at Bool Lagoon in 1980 and examined in this study were considered to be primarily adult birds, which may have previously bred (females), although at the time of collection they had apparently regressed or undeveloped gonads (male testes were of similar size to those from freckled duck shot in Victoria, Norman & Norris 1982; in that sample the testes showed minimal reproductive activity). Most birds also showed well-developed fat deposits, and had a body mass similar (and as high) as those examined in Victoria in 1981, reflecting good physiological condition. As in that study, few ducks from Bool Lagoon had missing or growing tail feathers, primary and secondary feathers were not heavily abraded (and had, for the most part, apparently been replaced some time before the opening day, 1 March), and the incidence of body moult was extensive. Norman & Norris (1982) concluded that the Victorian sample represented birds congregating at a more permanent wetland, one used as a refuge during drought elsewhere. Freckled duck present at Bool Lagoon in March 1980 were apparently behaving in a similar fashion, concentrating outside the normal breeding range, in a semi-permanent wetland which provided drought refuge.

The freckled duck is largely sedentary but, in drier seasons, as habitat is reduced they disperse to more coastal refuge areas like Bool Lagoon (*e.g.* Frith 1982, Marchant & Higgins 1990). In Victoria, the reporting rate for this species was highest in early summer, and there were no records from May to July (Emison *et al.* 1987). In South Australia too, freckled duck tend to increase in south-eastern wetlands during summer-autumn periods (L. Best, pers. comm.). However, such dispersal is irregular in southern Australia. Bag surveys conducted between 1972 and 1979 (Braithwaite & Norman 1974, 1976, 1977, 1982; Norman *et al.* 1982) showed that few (<1%) of the ducks examined were freckled duck. However, in 1980 the proportion increased to 4.5% in Victoria (Norman & Norris 1982) and at Bool Lagoon too, numbers of freckled duck, as reflected in counts and hunter surveys, were greatest in 1980 (L. Best, pers. comm.). These irruptions apparently follow extensive inland flooding and subsequent drying periods. Parker *et al.* (1985) considered that there was a 5–9 year cycle in irruptions, related to events within the Lake Eyre basin (rather than the Lachlan–Murrumbidgee basin, *cf.* Frith 1982); a major flood occurred in the Eyre basin in 1976, and a minor one in 1977 (Marchant & Higgins 1990). From mid to late 1979, freckled duck numbers increased in south-eastern Australia and many were shot in the 1981 season (Norman & Norris 1982). Numbers at Bool Lagoon increased from September 1979 onwards, and by March 1980 there were up to 5 000 freckled duck present, of which at least 436 (and perhaps as many as *ca* 1 000) were shot (L. Best, pers. comm.; L. C. Jolley, in litt.). Despite this, some 200–300 were present between April and June but few in subsequent seasons (L. Best, pers. comm.).

In the Bool Lagoon area at least, the freckled duck, a specialist feeder (Marchant & Higgins 1990), was able to maintain body weight and fat reserves by taking a range of foods from both plant and animal sources. The species, whose status is unresolved, should be protected at such refuge wetlands.

Acknowledgments

Data presented here were derived from freckled duck examined, in part at least, by others. We thank the late S. A. Parker (then Curator of Birds, South Australian Museum) who initiated this study. He collected carcasses (with the assistance of South Australian National Parks and Wildlife Service staff), and organised the preparation of specimens and collection of data. We also thank L. W. Braithwaite and I. Mason, CSIRO Division of Wildlife and Ecology, for providing details of moult, wing wear and other measures for some birds. Ectoparasites were determined by K. C. Emerson (Smithsonian Institution, Washington), endoparasites by the late L. M. Angel (South Australian Museum), and food material determined by H. Aston (National Herbarium, Victoria), B. J. McHenry (South Australian Museum), B. Smith (Museum of Victoria), and J. Walker (Medical Parisitology Unit, Westmead Hospital, NSW).

We are grateful to L. Best, National Parks and Wildlife Service, Department of Environment and Planning, South Australia, for the provision of data regarding numbers of freckled ducks found in hunters' bags, or discarded, at Bool Lagoon in various years. The late Shane Parker, S. V. Briggs and R. T. Kingsford provided useful comments on an earlier draft of this note.

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DISCOVERY OF A POPULATION OF THE RARE SCINCID LIZARD, *TILIQUA ADELAIDENSIS* (PETERS).

The scincid lizard *Tiliqua adelaidensis*, known as the Adelaide or pygmy bluetongue lizard, is probably the most enigmatic Australian reptile. It has been regarded as endangered if not extinct, with the last specimens being seen 33 years ago. We report here on the recent collection of specimens of *Tiliqua adelaidensis* which show that a wild population still exists. Discovery of this population will enable the gathering of the first data on the habits and ecology of this elusive lizard.

Tiliqua adelaidensis has been known from a total of only 20 specimens (G. Shea, pers. comm.) accumulated over 130 years. It was described as *Cyclodus adelaidensis* (Peters, 1863) from two specimens sent by Richard Schomburgk to the Berlin Museum, which holds five additional specimens. Other specimens found their way to the Natural History Museum, London (one), and the Naturhistorisches Museum, Vienna (three), while the South Australian Museum held eight specimens and the Museum of Victoria one.

The species was seldom mentioned subsequent to its description, and was apparently already very rare by the 1920's. Waite (1929) doubted that the species occurred in South Australia or even whether it was a distinct species and not a misidentified juvenile of one of the larger species. The species has been reported only twice this century. During the 1940s two specimens were donated to the S.A. Museum by a Burra resident, while the most recent sighting was at Marion, where two individuals were collected in October 1959 (both finds extensively discussed by Ehmann, 1982).

The extant specimens provide morphological information and some dietary data (Ehmann, 1982) but little else. In spite of Waite's doubts, the species is a valid but dwarfish member of the genus *Tiliqua*. Its dentition is distinctive (Shea & Hutchinson, 1992), the reduced dark patterning of scattered longitudinal series of irregular small blotches is unlike that of any other member of the genus and *T. adelaidensis* also shows weaker development of the specialised occipital and nuchal scalation typical of other, larger species in the genus. The diet assessed from preserved specimens appears to include both invertebrates and plant material (Ehmann, 1982).

A crucial deficiency has been the lack of any or adequate locality and habitat data accompanying the specimens. The few known localities extend from the Adelaide Plains and Mt Lofty Ranges northwards as far as Burra (Ehmann, 1982; Hutchinson, 1992; G. Shea, pers. comm.). About half of the specimens have no precise data, while some localities associated with specimens may be no more than addresses of the consigners of the specimens. All localities are from a small area of South Australia lying between the Adelaide Plains (Marion) and the North Mt Lofty Ranges (Burra). The type specimens were reportedly from 'stony, sandy terrain' but it is not clear whether they were collected near Schomburgk's property, Buchsfelde, west of Gawler, or from further afield. Meagre data accompanying specimens from Dry Creek railway station and Marion, both in Adelaide's suburbs, suggest a semi-fossorial way of life; at both localities the specimens were collected from cryptic retreats, under stones in the case of Dry Creek and from a burrow under a shed floor in the case of Marion. Unfortunately these localities are highly modified, revealing nothing of the species' natural habitat.

During the late 1960s to early 1980s vigorous attempts were made to relocate *T. adelaidensis* (partly documented by Ehmann, 1982). These attempts met with no success, and recent assessments of the species' status have been pessimistic. Prior to the discoveries reported here, it was becoming regarded as the the only one of over 700 Australian reptile species to have become extinct since European settlement (Wilson & Knowles, 1988; Hutchinson, 1992; Ehmann, 1992; Cogger, 1992). Extensive vegetation clearance, urbanisation, habitat modification generally and even mouse plagues have been blamed for the species' decline (Ehmann, 1982; 1992; Kennedy, 1990; Hutchinson, 1992).

The new specimens

The discovery of the population was made under unusual circumstances since the first specimens were found dead after having been taken by predators.

The first was collected on 14 October, 1992, by GA and JRWR while they were engaged in the joint Department of Environment & Land Management and South Australian Museum vertebrate survey of the South Olary Plains region. They collected a recently road-killed eastern brown snake (*Pseudonaja textilis*, Elapidae; SAMA R40688) which upon dissection in the field was found to contain a nearly perfect *Tiliqua adelaidensis* (R40687). The precise locality is obtainable from the South Australian Museum Herpetology Section, but is in the general vicinity of Burra, the area from which two of the previously collected specimens are known to have come.

R40689 was collected six days later, found freshly killed with still-bleeding neck and posterior head wounds. A group of three Australian kestrels (*Falco cenchroides*) inhabited the immediate vicinity of the discovery site and had a nest about 50 metres from where the body was found. The damage to the lizard is consistent with its having been caught and killed by

FIGURE 1. The first live specimen of *Tiliqua adelaidensis* from the newly discovered population. Snout-vent length of specimen 67 mm.

a kestrel (P. Horton, pers. comm.). This specimen was found approximately 8 km (air-line) from the site of the first. The third (R40728) and fourth (R40738) specimens were collected near the first. R40728 was found on 29 October, decapitated and partly eviscerated. Again this is consistent with the lizard having been taken by a bird of prey. R40738 was found on 4 November in the gut of another *P. textilis* which had been collected adjacent to the collection sites of R40687 and R40728.

The second, third and fourth finds were made in the course of establishing a pilot trapping study to ascertain if live specimens could be caught using conventional herpetological survey methods. This rapidly proved to be the case, with the first live male being caught in a pit trap on the afternoon of 6 November. The field study is continuing and further specimens have been found. The results of this work will be published shortly (Hutchinson & Milne, in prep.).

Discussion

A total of 18 additional reptile species have been collected from the immediate vicinity of the *T. adelaidensis* sites, with most species being recorded near more than one site, indicating similar ecological and faunal associations. Most notable are four species which are confined to or strongly associated with the Flinders Ranges-Mt Lofty Ranges area: *Ctenophorus decresii*, *Aprasia pseudopulchella*, *Delma molleri*, and an undescribed species of *Gehyra* (the 2n = 44 'variegata' of King, 1979). The long-term land use practices in the region have evidently allowed a significant number of reptile species to persist in spite of the almost complete elimination of the natural vegetation.

It is encouraging that *T. adelaidensis* has managed to survive in a far from natural habitat for a considerable time, although population size and current dynamics (declining, stable or increasing) are unknown. At this early stage, it is obviously not possible to reassess the conservation status of the species, and it should retain its 'endangered' classification. The pilot field study is intended as a first step, and must lead to more comprehensive surveys aimed at establishing the size and extent of the population, so that this species can be understood and its survival made secure.

ACKNOWLEDGMENTS

We thank the owners of the Burra area properties who allowed us access to their land. T. Milne, B. Miller and D. Armstrong assisted with field work and many other aspects of the initial study, which was funded by the following sources: Murray Valley Commission; Endangered Species Unit, Australian National Parks & Wildlife Service; South Australian Department of Environment & Land Management; South Australian Museum. G. M. Shea, University of Sydney, kindly made available his unpublished thesis description of the known *T. adelaidensis* specimens.

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S 736 / 32
no 504

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VOLUME 27
1994

Published by the South Australian Museum,
North Terrace, Adelaide, South Australia 5000.

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Volume 27(1) was published on 5 July 1994.
Volume 27(2) was published on 28 October 1994.

ISSN 0376–2750

MUSEUM OF VICTORIA
11 JUL 1994

RECORDS OF THE BRYOZOAN FAMILY SELENARIIDAE FROM WESTERN AUSTRALIA AND SOUTH AUSTRALIA, WITH THE DESCRIPTION OF A NEW SPECIES OF *SELENARIA* BUSK, 1854

S. A. PARKER & P. L. COOK

PARKER, S. A. & COOK, P. L. 1994. Records of the bryozoan family Selenariidae from Western Australia and South Australia, with the description of a new species of *Selenaria* Busk, 1854. *Rec. S. Aust. Mus.* **27**(1): 1–11.

Unlike that of Bass Strait, the selenariid fauna of southern Western Australia and South Australia is relatively poorly known. A first estimate of its diversity is presented here, based on a study of 514 colonies (in 100 samples), mostly previously unreported specimens collected by Sir Joseph Verco (1851–1935). The study confirms an earlier suspicion that *Selenaria hexagonalis* Maplestone, 1904 actually consists of two species, here distinguished as *S. hexagonalis sensu stricto* and *S. verconis* sp. nov. In all, 16 species are represented, of which 11 constitute new records for the region (South Australia: *Otionella nitida* (Maplestone, 1909), *O. australis* Cook & Chimonides, 1985b, *Selenaria punctata* Tenison-Woods, 1880, *S. concinna* Tenison-Woods, 1880, *S. varians* Cook & Chimonides, 1987, *S. exasperans* Cook & Chimonides, 1987, *S. verconis* sp. nov. and *'S'. alata auctt.* (*non* Tenison-Woods, 1880); Western Australia: *S. bimorphocella* Maplestone, 1904, *S. concinna*, *S. hexagonalis* and *S. verconis* sp. nov). Brief descriptions of the genera and species are provided.

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The calcareous element of southern Australian shelf sediments contains in places a high proportion of living bryozoans and dead bryozoan skeletons (Wass *et al.* 1970, James *et al.* 1992). Although many bryozoans live in or on such sediments, the free-living cup-shaped (lunulitiform) species of the anascan family Selenariidae can be particularly abundant in this zone. However, no idea of the abundance and diversity of selenariids in southern Australia was received until the appearance of Cook and Chimonides's studies on the Australasian Selenariidae (Cook & Chimonides 1984a, b, 1985a–c, 1986, 1987). From the Tertiary to the Recent of southern Australia (mainly Victoria and Bass Strait), these authors listed four genera (one new) and 43 species (18 new), many of the latter with an extensive temporal, and sometimes a wide geographical, range.

The marine invertebrate collections of the South Australian Museum include much material obtained by Dr Sir Joseph Verco in the years 1890–1912. Verco was principally interested in molluscs, and the chief method he employed to obtain these (dredging) resulted in the collection of other benthic groups such as brachiopods (Verco & Blochmann 1910), turbinoliid scleractinians (Cairns & Parker 1992) and selenariid bryozoans.

In 1904, in correspondence to Sir Sidney Harmer, C. M. Maplestone mentioned Verco's selenariid collections, and offered to have specimens of his own new species *Selenaria hexagonalis* and *S. bimorphocella*, sent to Harmer by Verco. Subsequently, Livingstone (1928), in discussing Verco's bryozoans in the SAM, listed two samples under *Selenaria punctata* Tenison-Woods and one under *Lunularia capulus* (Busk); comments on these identifications are given below.

Apart from these instances, Verco's selenariids have remained unreported. Inasmuch as his collecting stations ranged from the south-east of South Australia (off Beachport and Cape Jaffa) westward to the Albany and King George Sound districts of Western Australia, they complement those reported by Cook and Chimonides, which were mainly in the Bass Strait, with one off Jurien Bay near Perth.

Verco's selenariid material in the SAM numbers 48 samples. This was augmented by other material, including 19 Verco samples in the QM, four samples from off Perth, 1963 (QM), four from Western Australia (WAM) and four from South Australia, 1982–1991 (SAM). The following article lists the 16 species involved, together with synonymies, references to recent redescriptions, details of material examined, notes on Recent and

[1] (Shane Parker died in November 1992. This paper was then in the final stages of preparation, P.L.C.).

fossil distribution and bathymetric range, and remarks on the distinguishing features of the species and genera.

Materials and methods

Abbreviations of institutions referred to in this paper are: BMNH, Natural History Museum, London; NMV, Museum of Victoria, Melbourne; QM, Queensland Museum, Brisbane; SAM, South Australian Museum, Adelaide; WAM, Western Australian Museum, Perth.

Five hundred and fourteen specimens (colonies) in 100 samples were examined, of which 406 specimens in 69 samples were collected by Sir Joseph Verco. By institution, the material was constituted as follows: SAM: Verco Coll. 268(48), other sources 78(20); QM: Verco Coll. 136(19), other sources 5(4); NMV: Verco Coll. 1(1), other sources 1(1); BMNH: Verco Coll. 1(1), other sources 2(2); WAM: other sources 22(4). Among the specimens examined were five syntypes of *Lunulites patelliformis* Maplestone, 1904 (= *Lunularia capulus* Busk, 1852a) and the lectotype of *Selenaria hexagonalis* Maplestone, 1904. All specimens were Recent except for a Pliocene paratype of *S. verconis*. Unless otherwise specified, all specimens referred to under *Material Examined* were collected by Verco.

Notes on lunulitiform colonies

Although some lunulitiform colonies are attached by rhizoids to shell fragments etc., on the sea-bottom, the free living species are unattached and are stabilized and supported by the elongated avicularian mandibles of the peripheral regions of the colony. Some species are capable of locomotion (see Cook & Chimonides, 1978 and Chimonides & Cook, 1981). They live in, or upon the upper centimetres of sediment, where their dead skeletons also accumulate. Colonies rarely exceed 25 mm in diameter and are conical, cup-shaped or discoid. Each colony, whether spirally or radially budded, has patterned groups of feeding zooids (autozooids) and avicularia, which have elongated, paddle-shaped or whip-like mandibles. Large brooding zooids tend to be found subperipherally or peripherally, and in the genus *Selenaria*, very large, specialized, non-feeding male zooids occur peripherally among enlarged avicularia.

Some species, or populations within species, seem to have particular depth and/or temperature tolerances. For example, living *Selenaria maculata* is common in only 2–4 m in Queensland, but has been found at 146 m in New South Wales; *Otionella affinis* thrives at nearly 250 m off New Zealand. Generally, the most abundant and diverse living fauna seems to occur between 50 and 130 m depth. The material examined here shows few exceptions, but nearly all the best preserved colonies with mandible and frontal membranes intact, which may be inferred to have been alive when collected, occur from depths shallower than 60 m. The exceptions are *Helixotionella spiralis* and *H. scutata*, which together with *S. pulchella* were all originally collected alive from off Jurien Bay, Western Australia at 137 m. All three species were collected alive by Verco from off Albany at 147 m (see below), which suggests that their tolerances are normally at the deeper end of the range.

Systematics

Order Cheilostomatida Busk, 1852b

Suborder Anasca Levinsen, 1909

Superfamily MICROPOROIDEA Gray, 1848

Family SELENARIIDAE Busk, 1854

Genus *Lunularia* Busk, 1884

Zooids large with limited cryptocyst, budded radially; avicularia large, simple, with paddle-shaped mandibles; large brooding zooids scattered.

Lunularia capulus (Busk, 1852a)

Lunulites capulus Busk, 1852a: pl. 1, figs 13, 14. 1854: 100, pl. 112.

Lunulites gibbosa Busk, 1854: 100, pl. 111.

Lunulites patelliformis Maplestone, 1904: 215, pl. 25, fig. 6.

Selenaria livingstonei Bretnall, 1922: 190, figs 2, 2a.

Lunularia capulus: Livingstone 1924: 198, 1928: 115; Cook & Chimonides, 1986: 691, figs 6, 9, 12–14.

Material Examined

South Australia: Petrel Bay, St Francis I., 19 fms (34.8 m), SAM L532(1); 13 Nm (nautical miles) (23.8 km) ESE of Troubridge Point, 35 m, K. L. Gowlett-Holmes and S. Corigliano 11–12.vi.1991, SAM L675(1); Investigator Strait, 20 fms (36.6 m), SAM L395(1); Gulf St Vincent, SAM L492–496(5) (syntypes of *Lunulites patelliformis* Maplestone); W of Aldinga, Gulf St Vincent, 38–41 m, K. L. Gowlett-Holmes and S. Corigliano 4–5.v.1987, SAM L533(1); Emu Bay, Kangaroo I., *ca* 35 m, J. Gehling 4.iv.1984, sandy bottom, SAM L549(2); no data, SAM L535, 536(2).

Distribution

Previously known from Torres Straits, Queensland, New South Wales, Victoria, Bass Strait (including Bank Strait between Flinders I. and Tasmania), South Australia and south-western Western Australia, 27.5–167 m, with fossil records from the Miocene and Pliocene of Victoria and the Pliocene of South Australia and Western Australia. Previous South Australian records are from Investigator Strait, Gulf St Vincent and Backstairs Passage; the present material adds St Francis I. and Kangaroo I. to the known range in that State.

Remarks

Of the 13 colonies examined, seven were alive when collected. *L. capulus* is characterized by its large, deeply domed zoaria, and autozooids and avicularia alternating in distally contiguous radial series. The three colonies of L549(2) and L675(1) are the largest so far seen by us, measuring 34, 34 and 35 mm in diameter respectively.

One of the two colonies of L549 bears on its basal surface good examples of basal buds (structures previously described by Cook & Chimonides, 1986: 697–698).

The sheltered, strongly concave basal surface of *L. capulus* is often colonized by other bryozoans. In the present specimens, the most frequent of these is the microporid *Mollia multijuncta* (Waters, 1879), which occurs in samples L492, L532, L549 and L675. The two zoaria of L549 bear also basal colonies of a species of *Arachnopusia* Jullien, 1888, *Chorizopora brongniartii* (Audouin, 1826), *Microporella lunifera* Haswell, 1880 and three species of *Parasmittina* Osburn, 1952. Apart from the small area of *M. multijuncta*, L675 is almost completely encrusted basally with *Membranipora perfragilis* (MacGillivray, 1881), and supports also a small colony of *Scrupocellaria* sp. and a minute individual (3 mm diameter) of a scleractinian coral, probably *Scolymia australis* (Milne Edwards & Haime, 1849). On the basal surface of L533 occurs yet another bryozoan, *Crassimarginatella pyrula* (Hincks, 1881).

Cook (1985: 23–24, 93) discussed the occurrence of acrothoracid cirripedes in large lunulitiform bryozoans, particularly that of *Kochlorinopsis discoporellae* Stubbings, 1967 in West African populations of the cupuladriid bryozoan *Discoporella umbellata* (Defrance, 1823). In our material, these barnacles have been present in samples L492, L532, L533 and L675, as attested by the small slits at the apex of the colonies.

Lunularia repanda (Maplestone, 1904)

Lunulites repandus Maplestone, 1904: 216, pl. 25, fig. 7.

Lunularia repandus: Cook & Chimonides, 1986: 698, figs 7, 8, 10, 15, 16.

Material Examined

Western Australia: 32°S., 115°08'E., off Perth, 119 m, B. Jamieson 28.viii. 1963, QM GH1150(1); King George Sound, 12–14 fms (22–25.6 m), SAM L537(1), 28 fms (51 m), SAM L538(1), 35 fms (64 m), QM GH1693(1); 80 Nm (146.4 km) W of Eucla, 81 fms (148 m), iii.1912, SAM L539(1), 140 fms (256 m), SAM L540(1).

South Australia: Off St Francis I., 35 fms (64 m), SAM L541(1); cove NW of Petrel Cove, St Francis I., 40 m shifting sandy bottom, W. Zeidler & N. Holmes 28.i.1982, SAM L548(3); S of Troubridge I., 20 fms (36.6 m), SAM L542(1); Beachport, 150 fms (275 m), SAM L543(1); no data, SAM L534(1), L544–547(36).

Distribution

Previously known from south-western Western Australia, South Australia and Bass Strait (27.5–183 m) and from the Kermadec Ridge (145–350 m; see Gordon, 1984), and by fossils from the Miocene of New Zealand. The present material adds King George Sound and 80 Nm (146.4 km) W of Eucla to the known Western Australian range, and St Francis I. and Beachport to the known South Australian range, and increases the recorded depth-range to 22–275 m.

Remarks

Of the 49 colonies examined, 29 were alive when collected. *L. repanda* differs from *L. capulus* in having flatter zoaria, and the autozooids in radial series not alternating with series of the avicularia which are very large and scattered. One sample (SAM L547) comprised 18 colonies, several of which exceeded 29 mm in diameter. Colonies in SAM L542 and L548 bore the bryozoan *Mollia multijuncta* (Waters, 1879) (Microporidae) on their basal surfaces.

Genus ***Otionella*** Canu & Bassler, 1917

Zooids budded radially, with small, rounded opesiae. Ancestrula with one distal and one proximal adjacent avicularium. Brooding zooids enlarged, marginal.

Otionella squamosa (Tenison-Woods, 1880)

Selenaria squamosa Tenison-Woods, 1880: 29, fig. 29.

Otionella squamosa: Cook & Chimonides, 1984a: 232, figs 2, 6, 7, 14 g,h, 15, 21E; 1985b: 586, figs 16, 17; Gordon, 1986: 71, pl. 28C.

Material Examined

?South Australia: no data, SAM L550(1).

Distribution

O. squamosa has been reported from Torres Strait, New South Wales, Bass Strait (20–121 m) and New Zealand (1092.5 m), and as a fossil from Victoria and Bass Strait (Pliocene) and New Zealand (Pleistocene). The present specimen, though without details of provenance, is most likely from South Australia.

Remarks

O. squamosa is distinguished by its large, scattered, usually asymmetrical avicularia, with marginally perforated cryptocyst, and prominent condyles unfused or fused on the basal side only.

Otionella nitida (Maplestone, 1909)

Selenaria nitida Maplestone, 1909: 271, pl. 77, fig. 8.
Otionella nitida: Cook & Chimonides, 1984a: 239, figs 14f, 16, 18–20, 21B; 1985b: 584, figs 14, 15, 29.

Material Examined

South Australia: Backstairs Passage, 'deep water', SAM L551(1); Cape Jaffa, QM GH1642(1); no data, SAM L552(4), L553(1).

Distribution

Previously known from south-western and mid-western Western Australia, Bass Strait and New South Wales (17–148 m), with fossil records from south-western Western Australia (Pliocene) and New Zealand (Pleistocene, Miocene). The present material adds South Australia to the Recent distribution of the species.

Remarks

Of the seven colonies examined, two were alive when collected. Colonies of *O. nitida* are very small and domed; the small, symmetrical avicularia, which may occur in contiguous radial series, have a perforated cryptocyst and fused condyles.

Otionella australis Cook & Chimonides, 1985b

Otionella australis Cook & Chimonides, 1985b: 590, figs 11, 12, 23–25.

Material Examined

Western Australia: 32°S., 115°08'E., off Perth, 119m, B. Jamieson 28.viii. 1963, QM GH1150(2); King George Sound, 35 fms (64 m), QM GH1693(3); 80 Nm (146.4 km) W of Eucla, 81 fms (148 m), iii.1912, SAM L554(49); W of Eucla, 50–120 fms (92–220 m), iii.1912, SAM L555(4); 40 Nm (73.2 km) W of Eucla, 72 fms (132 m), iii.1912, SAM L556(2).

South Australia: Cape Jaffa, QM GH1642(55); off Cape Jaffa, 90 fms (165 m), SAM L557(1), 130 fms (238 m), SAM L558(1); no data, SAM L559(1), L560(2).

Distribution

Previously known from south-western Western Australia and Bass Strait, 84–137 m and in the fossil record from south-western Western Australia (Pliocene) and Victoria (Miocene). The present material adds South Australia (south-eastern) and the Western Australian sector of the Great Australian Bight to the species' known distribution, and extends the depth-range to 238 m.

Remarks

Of the 62 colonies in the SAM, 25 were alive when collected. *O. australis* is distinguished by the simple, scattered, almost symmetrical avicularia with long serrated opesiae and large unfused condyles. Most specimens examined (dried or in alcohol) were of a pale blue or deep reddish colour.

Genus ***Helixotionella*** Cook & Chimonides, 1984b

Zooids budded in paired interdigitating spirals. Avicularia with setiform mandibles. Brooding zooids with enlarged opesia.

Helixotionella spiralis (Chapman, 1913)

Selenaria marginata var. *spiralis* Chapman, 1913: 184, pl. 18, fig. 33.
Helixotionella spiralis: Cook & Chimonides, 1984b: 257, figs 6–10, 13, 14, 17, 18, 1987: 962.

Material Examined

Western Australia: 32°S., 115°08'E., off Perth, 119 m, B. Jamieson 28.viii. 1963, QM GH1150(1); 80 Nm (146.4 km) W of Eucla, 81 fms (148 m), iii.1912, SAM L561(2).

Distribution

Previously known from 40 km west of Jurien Bay, Western Australia, 137.2 m, with fossils from Victoria (Oligocene to Pliocene). The present material adds two localities to the species' range in southern Western Australia (one in the Great Australian Bight), and increases the recorded depth-range to 119–148 m.

Remarks

The two colonies in the SAM were alive when collected. In this species, the paired interdigitating

spirals of zooids form the entire minute colony, which rarely exceeds 2 mm in diameter. The avicularian opesia is serrated and the condyles unfused. There is usually only one pair of basal avicularia.

H. spiralis is remarkable for the extent of its temporal range, from Oligocene to Recent (Cook & Chimonides, 1987: 962).

Helixotionella scutata Cook & Chimonides, 1984b

Helixotionella scutata Cook & Chimonides, 1984b: 265, figs 3–5, 11, 15, 16, 19.

Material Examined

Western Australia: 80 Nm (146.4 km) W of Eucla, 81 fms (148 m), iii.1912, SAM L562(9).

Distribution

Previously known only by the type series from 40 km west of Jurien Bay, south-western Western Australia, 137.2 m. The present material adds the Western Australian sector of the Great Australian Bight to the known distribution of this species, and increases its recorded depth-range to 148 m.

Remarks

The nine colonies examined were all alive when collected. *H. scutata* is distinguished by its bifurcated spiral series of zooids, and by its avicularia having fused condyles and an opesia obscured by a flattened scuta.

Genus ***Selenaria*** Busk, 1854

Zooids budded radially in successive zones. Central zone of closed zooids, surrounded by autozooids and avicularia. Next zone composed of enlarged, female brooding zooids, next zone of peripheral, non-feeding male zooids. Avicularia large, scattered, with S-shaped or reflexed condyle system, mandibles very long, formed from alternating discs of calcified and cuticular tissue.

Selenaria bimorphocella Maplestone, 1904

Selenaria bimorphocella Maplestone, 1904: 213, pl. 24, fig. 3; Cook & Chimonides, 1985a: 301, figs 5d, 15, 16.

Selenaria punctata: Livingstone (non Tenison-Woods) 1928: 114.

Material Examined

Western Australia: 60 Nm (109.8 km) W of Eucla, SAM L563(1); W of Eucla, 50–120 fms (92–220 m), SAM L564 (1); W of Eucla, 72 fms (132 m), QM GH1714(1).

South Australia: 35 Nm (64 km) SW of North Neptunes, 104 fms (190 m), i.1905, SAM L565(3); E of North Neptunes, 45 fms (82 m), SAM L549(1); S of Troubridge I., 20 fms (36.6 m), SAM L567(2); Investigator Strait, 20 fms (36.6 m), SAM L416(3); Investigator Strait, 2 fms (3.7 m),17 fms (31 m) and 20 fms (36.6 m) QM GH1668(21), and no depth, SAM L568(1); off Point Marsden, Kangaroo I., 15 fms (27.5 m), QM GH1646(4); off Ardrossan, 6–8 fms (11–14.6 m), SAM L373(1); Gulf St Vincent, 12 fms (22 m), QM GH1673(1), 17 fms (31 m), SAM L566(77); Yankalilla Bay, 20 fms (36.6 m), SAM L569(6); Backstairs Passage, 17 fms (31 m), QM GH1636(9) and no depth, SAM L570(56); between Backstairs Passage and The Pages, 25 fms (46 m), SAM L572(1); Cape Jaffa, 90 fms (165 m), QM GH1639(1), 1643(1) Beachport, SAM L572(1); no data, SAM L573–577(32).

Distribution

Previously recorded from South Australia (Gulf St Vincent, Investigator Strait and south of Eyre Peninsula) and Bass Strait, 31–183 m, and as fossils from the Pliocene of Victoria. The present material extends the known range westward to the Western Australian sector of the Great Australian Bight, and adds several localities to the South Australian distribution, notably Cape Jaffa and Beachport in the South-East; it also increases the depth range to 3.7–220 m.

Remarks

Of the 172 SAM colonies examined, 45 were alive when collected; L373 and L416 are the samples reported by Livingstone (1928) as *S. punctata*. A further sample identified by Livingstone (MS) as *S. punctata*, from Yankalilla, consists of five colonies of *S. bimorphocella* (L569) and one of *S. concinna* Tenison-Woods, 1880 (L583).

The colonies of *S. bimorphocella* are large and flat, with very large ancestrulae. The species is distinguished by the considerable sexual dimorphism of the zooids (the male zooids having a trifoliate opesia and no opesiules), and the autozooidal cryptocyst having a sinuate opesia.

Pace Cook & Chimonides, 1985a: 303, *S. bimorphocella* does not replace *S. punctata* along the southern coasts of Australia, for the latter does occur there in small numbers (see below). However, to judge from the large number of samples in the present material, *S. bimorphocella* seems to be by far the commonest selenariid in the region.

Selenaria punctata Tenison-Woods, 1880

Selenaria punctata Tenison-Woods, 1880: 9, pl. 2, figs 8a–c; Cook & Chimonides, 1985a: 303, figs 5e, 9, 10, 17, 19.

Selenaria fenestrata Haswell, 1880: 42.
Selenaria partipunctata Maplestone, 1904: 214, pl. 24, fig. 4.

Material Examined

Western Australia: 32°S., 115°08'E., off Perth, 119 m, B. Jamieson 28.viii. 1963, QM GH1150(1); 80 Nm (146.4 km) W of Eucla, 81 fms (148 m), SAM L578(2); 19°32'S., 118°08'E., NW of Port Hedland, 50–52 m, 26.iii. 1982, WAM 4–92(1); 20°19'S., 116°47'E., off Legendre Id, 42 m, WAM 1864–88(19); Mermaid Sound, Dampier Archipelago, 10.ii.1981, WAM 2–92(1); between Dampier and Port Hedland, WAM 87–89(1).

South Australia: Off Cape Jaffa, 130 fms (238 m), SAM L579(1).

Distribution

Previously recorded from Western Australia, eastern Queensland and New South Wales, 11–137 m, also as a fossil from south-western Western Australia (Pliocene). The present material adds South Australia (South-East) and the Western Australian sector of the Great Australian Bight to the known range of the species, and extends the lower depth-range to 238 m.

Remarks

As noted above, Livingstone's (1928) report of *S. punctata* from South Australia is referred to *S. bimorphocella*. The colonies of *S. punctata* are small, domed, with small ancestrulae; the autozooidal opesiae are D-shaped with closely-apposed opesiules; brooding zooids have a bar across the orifice, and male zooids have long, paired opesiules. Some of the colonies from Western Australia (SAM) have a diameter of only 3 mm and still retain frontal membranes, but few or no mandibles, many of the others (WAM) are worn. The colony from South Australia is very worn.

The widespread *S. punctata* is very similar to *S. parapunctata* Cook & Chimonides, 1985a, which appears to replace it in Bass Strait (see Discussion). *S. parapunctata* differs by its widely spaced opesiules, absence of an orificial bar in brooding zooids, and S-shaped, rather than reflexed avicularian condyles.

Selenaria pulchella MacGillivray, 1895

Selenaria squamosa var. *pulchella* MacGillivray, 1895: 48, pl. 7, fig. 13.
Selenaria pulchella: Cook & Chimonides, 1984b: 262; 1985a: 307, figs 4, 20.

Material Examined

Western Australia: 80 Nm (146.4 km) W of Eucla, 81 fms (148 m), SAM L580(3).

Distribution

Previously recorded from Jurien Bay, 137 m, south-western Western Australia, with fossils from the Miocene of Victoria. The present sample adds the Western Australian sector of the Great Australian Bight to the species' known range, and increases the depth-range to 148 m.

Remarks

Of the three colonies examined, two were alive when collected. The colonies of this species are minute (2–3 mm in diameter). The zooids have small lateroproximal opesiular indentations, the male zooids possess small paired opesiules, and the avicularia have punctate frontal shields. All three present colonies were sexually mature, with male zooids and large peripheral avicularia, though no mandibles were present.

Selenaria concinna Tenison-Woods, 1880

Selenaria concinna Tenison-Woods, 1880: 10, pl. 2, figs 11a–c; Cook & Chimonides, 1987: 950, figs 1, 11, 24, 28, 30.

Material Examined

Western Australia: 80 Nm (146.4 km) W of Eucla, 81 fms (148 m), SAM L581(1).

South Australia: 35 Nm (64 km) SW of North Neptunes, 104 fms (190 m), i.1905, SAM L582(2); Yankalilla Bay, 20 fms (36.6 m), SAM L583(1); Backstairs Passage, SAM L584(5); Cape Jaffa, 90 fms (165 m), QM GH1643(3).

Distribution

Previously recorded from eastern Queensland, New South Wales, Bass Strait and New Zealand, 33–148 m, and as a fossil from the Pliocene of Western Australia and the Miocene of Victoria. The present material adds South Australia and Western Australia, to the species' known range, and extends the lower depth-limit to 190 m.

Remarks

One of a complex of five very similar species (Cook & Chimonides, 1987), *S. concinna* is distinguished by its avicularia, which have a serrated proximal opesia and a distal calcified bridge. None of the present specimens is larger than 7 mm in diameter, and all are slightly worn.

Selenaria varians Cook & Chimonides, 1987

Selenaria varians Cook & Chimonides, 1987: 957, figs 2, 32, 33.

Material Examined

South Australia: 35 Nm (64 km) SW of North

Neptunes, 104 fms (190 m), i.1905, SAM L585(3); Cape Willoughby, Kangaroo I., 23 fms (42 m), QM GH3160(1).

Distribution

Previously recorded from Bass Strait and New South Wales, 46–95m. The present material adds South Australia to the known distribution of the species, and amplifies the depth-range to 42–190 m.

Remarks

The four colonies examined have a maximum diameter of 4 mm and are all slightly worn. *S. varians* is distinguished by its autozooidal opesiae becoming proportionately larger with astogeny. The avicularia have a marginally serrate opesia.

Selenaria exasperans Cook & Chimonides, 1987

Selenaria exasperans Cook & Chimonides, 1987: 957, figs 5, 12, 34, 35.

Material Examined

South Australia: 35 Nm (64 km) SW of the North Neptunes, 104 fms (190 m), i.1905, SAM L586(2); Cape Jaffa, 130 fms (238 m), SAM L587(1); Cape Jaffa, 90 fms (165 m), QM GH1639(2); Beachport, 110 fms (201 m), SAM L588(2).

Distribution

Previously recorded from Bass Strait and New South Wales, 79–148 m. The present series adds South Australia to the known distribution, and extends the depth-range to 238 m.

Remarks

S. exasperans is distinguished by the presence of a proximo- and disto-lateral avicularium beside the ancestrula, a pattern unique in the genus. Autozooidal opesiae are D-shaped, and avicularian opesiae serrate. All five colonies examined (maximum diameter 4 mm) are slightly worn, but clearly show the ancestrula and adjacent avicularia and autozooids.

Selenaria hexagonalis Maplestone, 1904
(Fig. 1, A)

Selenaria hexagonalis Maplestone, 1904 (part): 214, pl. 24, fig. 5; Cook & Chimonides, 1987 (part): 948, figs 10, 20, 21 (not figs 8, 22, 23, = *S. verconis* sp. nov.)

Material Examined

Western Australia: King George Sound, 28 fms (51 m), SAM L589(1); no data, SAM L590–592(22).

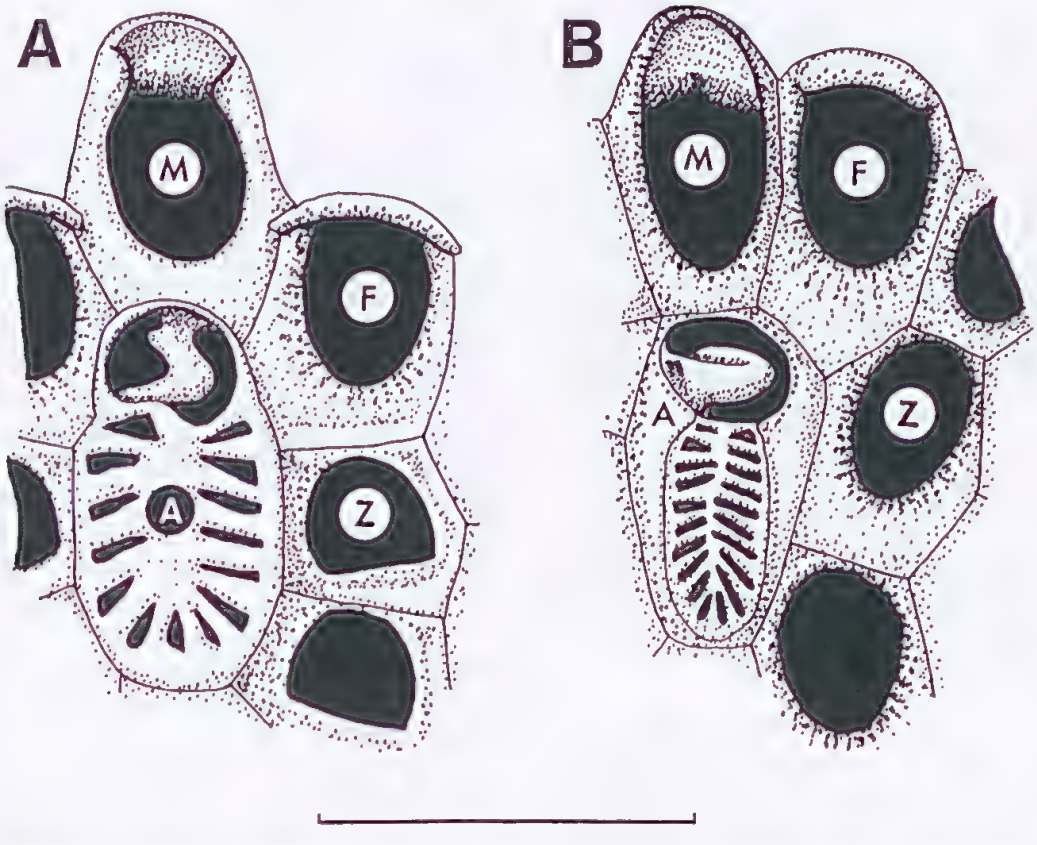

FIGURE 1. Sketches of zooids of *Selenaria*; M, male, F, female, Z, autozooid, A, avicularium. **A**, *S. hexagonalis* Maplestone. **B**, *S. verconis* sp. nov. Scale = 0.50 mm.

South Australia: Investigator Strait, 15 fms (27.5 m), NMV P62753, lectotype (selected by Cook & Chimonides, 1987: 948).

Distribution

Known from King George Sound, south-western Western Australia, 51 m and Investigator Strait, South Australia, 27.5 m.

Remarks

Colonies large (diameter 13–15 mm when sexually mature), robust and thickened basally. Autozooids hexagonal in frontal view, with subcentral, almost circular opesia. Centre of operculum just distal to centre of opesia. Subperipheral brooding zooids large, with elongated opesia, raised distally. Peripheral male zooids with very large, oval opesia, without subopercular tubercle. Avicularian shield with 12–16 stout bars, fused medially; condyle system not much reflexed, S-shaped.

The distinctness of this species from the next (*S. verconis* sp. nov.) was suspected by Cook & Chimonides (1987). *S. hexagonalis sensu stricto* has a more restricted range than *S. verconis* sp. nov., being known with certainty from only one district in Western Australia and one in South Australia.

One very large colony (one of the nine in SAM L591), 14 mm in diameter, had apparently ceased growing when 11 mm in diameter, just before sexual maturity. Subsequent growth around the perimeter is marked by swollen basal calcification and concentric series of brooding and male zooids, interspersed with large avicularia. The avicularia are orientated radially, and their condyle systems seem normal, but the frontal shield of bars of calcification is orientated at right angles to the normal direction. The setiform mandibles would not have been affected by the orientation of the frontal shield. The two other mature colonies in this sample show no abnormalities. One of the three colonies in sample SAM L592 has large acrothoracid cirripede burrows in the central area.

Selenaria verconis sp. nov.
(Fig. 1, B)

Selenaria hexagonalis Maplestone, 1904 (part): 214 (Jimmy's Point Farm, Victoria, Pliocene); Cook & Chimonides, 1987 (part): 948, figs 8, 22, 23.

Material Examined

HOLOTYPE: **Queensland**: Off Townsville, 2.5–12 m, coll. Cook & Chimonides, 1982, BMNH 1984. 12.24.14 (illustrated by scanning electron micrographs in Cook & Chimonides, 1987, figs 8, 22, 23).

PARATYPES: **Western Australia**: King George Sound, 22–28 fms (40–51 m), SAM L593(1), SAM L594(1); ditto, 28 fms (51 m), SAM L594 (1); 40 Nm (73.2 km) W of Eucla, 75–105 fms (137–192 m), iii.1912, SAM L596(1).

South Australia: Off Adelaide, 36–64 m, BMNH 1928.9.13.78.

Queensland: Port Denison, BMNH 1984.12.24.36.

Victoria (Pliocene): Jimmy's Point Farm, coll. Maplestone. NMV T1757. (Last three samples and holotype listed under *S. hexagonalis* by Cook & Chimonides, 1987: 948).

Description

Colonies 10–11 mm when sexually mature. Autozooids with oval or suboval opesia, proximal edge sometimes almost straight; cryptocyst finely serrated. Operculum dark, placed above the distal half of the opesia. Subperipheral brooding zooids large, raised distally. Peripheral male zooids with elongated oval or pyriform opesia; subopercular tubercle absent. Avicularian shield with 14–20 fine bars, fused medially; frontal area narrowing distally, flanked by cryptocystal margins of adjacent zooids; condyle system reflexed.

Etymology

Verconis, L., genitive singular of Verco (construing the surname as a noun of the Third Declension); named after Dr Sir Joseph Cooke Verco (1851–1935).

Distribution

Known from south-western Western Australia (King George Sound), South Australia (Gulf St Vincent) and eastern Queensland, 2.5–192 m, and as a fossil from the Pliocene of Victoria.

Remarks

When redescribing *S. hexagonalis*, Cook & Chimonides (1987) noted the wide range of character states shown by both Maplestone's specimens and those in the BMNH, concluding that two partly sympatric forms might be involved. The four colonies from Western Australia examined here, some of which were collected with *S. hexagonalis s. s.*, have the unequivocal character correlations of the Queensland specimens. This indicates, as previously suspected, that two distinct and sympatric species are present, one (*S. hexagonalis*) with a restricted distribution the other (*S. verconis*) with a wider geographical range and a fossil record.

S. verconis most resembles *S. hexagonalis* Maplestone, differing by its less robust zoaria, smaller and proportionately longer zooids with oval to suboval opesiae and more distal opercula, and by the avicularia having 14–20 fine bars (*vs* 12–16

stout bars in *S. hexagonalis*) and a more reflexed condyle system (see Fig. 1B).

'Selenaria' alata auctt.

Selenaria alata: Cook & Chimonides, 1985c: 339, figs 1, 2, 5, 9, 11–13 (Recent material only). *Non Selenaria alata* Tenison-Woods, 1880: 11, pl. 2, figs 12a–c.

Material Examined

South Australia: 35 Nm (64 km) SW of the North Neptunes, 104 fms (190 m), i.1905, SAM L597(3); no data, SAM L598(1).

Distribution

Known previously only from Bass Strait, 46–95 m. The present material adds South Australia to the recorded range of the species, and increases the lower depth-limit to 190 m.

Remarks

Of the four colonies examined, one was alive when collected. This species is characterized by its large, asymmetrical, unfused avicularian condyles and large trifoliate autozooidal opesiae.

The Recent colonies from Bass Strait were all regenerated from fragments, and differed slightly from fossil *S. alata* in their less trifoliate autozooid opesiae. The present specimens do not exceed 12 mm in diameter, and two have mandibles resembling those of *Otionella squamosa*, see Cook & Chimonides (1985c, fig. 11). The ancestrulae are all worn or partly obscured, but do not appear to be as large as those of the fossil colonies. The autozooidal opesiae resemble those of the Bass Strait population, and are only slightly trifoliate. The somewhat ambiguous character of Recent *S. alata auctt.*, which shares features with both fossil *S. alata* and *S. lata*, will be discussed in a later article (Bock & Cook in prep.). The character of the avicularian condyles and mandibles of *S. lata*, *S. alata* and *S. alata auctt.*, together with the absence of zones of distinctive brooding and male zooids, means that none of these three species can be referred to *Selenaria s. s.*, and they require a generic grouping of their own.

Discussion

The present collections, though sparse in comparison with those previously reported from Bass Strait and New Zealand (Cook & Chimonides, 1987 and references therein; Nelson *et al.* 1988), are nevertheless significant in that they allow a first estimate of the diversity of the Selenariidae occurring in southern Western Australia and South Australia. The 16 species listed constitute a fairly diverse fauna, comparable to that of Bass Strait with its 18 species. New State records are: Western Australia: *Selenaria bimorphocella*, *S. concinna*, *S. hexagonalis* and *S. verconis*; South Australia: *Otionella nitida*, *O. australis*, *S. punctata*, *S. concinna*, *S. varians*, *S. exasperans*, *S. verconis* and *'S'. alata auctt.* Whereas most of the new locality records constitute only minor range-extensions (e.g. *S. concinna*), the extension in some cases is considerable. For example, *Helixotionella spiralis*, *H. scutata* and *S. pulchella*, previously known in the Recent only from the Jurien Bay district of Western Australia, are reported from the Eucla district of the Great Australian Bight, some 1 700 km to the south-east. Sufficient samples have now been analyzed from Bass Strait to permit the suggestion that these last three species are today genuinely absent from that region (though *H. spiralis* and *S. pulchella* have a fossil record in Victoria), and that the Great Australian Bight may well mark the eastern limit of their modern distribution. In addition, *S. hexagonalis* is reported from the Albany district of Western Australia, over 2 000 km west of its previous western limits in South Australia, and *S. varians* and *S. exasperans* are shown to occur at St Francis I., 1 000 km west of their original localities in Bass Strait (with *S. exasperans* occurring also at the intermediate localities of Cape Jaffa and Beachport in south-eastern South Australia).

The distribution of the species-pair *S. punctata* and *S. parapunctata* is of particular interest. The former is now known from most parts of the Australian continental shelf except Bass Strait, the Northern Territory and northern Queensland. Its absence from relatively well-collected Bass Strait may be real; moreover, in Bass Strait it appears to be replaced by *S. parapunctata*, which so far has not been reported from elsewhere.

Of the 18 species currently known from Bass Strait, seven are still notably absent from collections made further west: these are *Otionella minuta*, *O. auricula*, *Selenaria initia*, *S. minor*, *S. maculata*, *S. kompseia*, and *S. maplestonei* (see Cook & Chimonides, 1985a, b; 1987). It is possible that at least some of these will eventually be found in South Australia and Western Australia. After the discovery of living *H. spiralis*, *S. pulchella*, *S. initia* and *S. minor* (originally described as fossils), it is possible that, with further collecting, other fossil species will also be discovered to be extant.

Acknowledgments

We thank Mary Spencer Jones (BMNH), John Hooper (QM) and Diana Jones (WAM) for information on specimens in their care, and Philip Bock (Royal Melbourne Institute of Technology) for examining and identifying for us the QM's holdings of selenariids.

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A CHECKLIST OF HELMINTH PARASITES OF AUSTRALIAN AMPHIBIA

DIANE P. BARTON

BARTON, D. P. 1994. A checklist of helminth parasites of Australian Amphibia. *Rec. S. Aust. Mus.* 27(1): 13–30.

This checklist includes all original references, and any other references which do more than repeat original work, of helminths occurring in Australian amphibians published up to 1992. Museum listings are also included, where available. Most records pertain to free-ranging animals; where they do not, they have been annotated appropriately.

Helminths are arranged as follows: Monogenea, Digenea, Cestoda, Nematoda, Acanthocephala, in both the parasite-host and host-parasite checklists.

Hosts are presented by family with consideration given to recent taxonomic changes.

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Manuscript received 20 August 1992.

Introduction

In 1939 May Young produced a checklist of helminth parasites recorded from Australian hosts. Thirteen amphibian hosts, infected with a total of 30 helminth species, were included. There has been no further compilation of solely Australian records from amphibians since then. The aim of this work is to produce an updated checklist of amphibian helminth parasites in Australia.

Included in this checklist are all original references, and any other references which do more than repeat original work, published up to 1992. Museum collections of amphibian parasites are also included, where available. Most records pertain to free ranging animals; where they do not, they have been annotated appropriately (e.g. experimental).

Comments on host taxonomy

Host names used in this checklist follow Cogger (1992), with the following exceptions:

i) *Kyarranus* Moore, 1958 is accepted as a valid genus (see Frost 1985).

ii) *Litoria pearsoniana* (Copland, 1961) is accepted as a valid species (see Frost 1985).

In the parasite-host checklist, host names are given as they were listed in the original publications. In the host-parasite checklist, the names have been updated to those used by Cogger (1992). The original names are also given with reference to the new name when there is an element of confusion.

All species formerly referred to the family Leptodactylidae are now placed in the family Myobatrachidae (see Cogger 1992).

All *Hyla* species are now referred to the genus *Litoria* (see Cogger 1992).

Limnodynastes dorsalis and *L. d. dumerilii* recorded from South Australia, Queensland and New South Wales are referred to *L. dumerilii*. *Limnodynastes dorsalis* is only present in Western Australia (see Cogger 1992).

Litoria aurea and *L. a. raniformis* recorded from South Australia, Victoria and Tasmania are referred to *L. raniformis* (see Cogger 1992).

Litoria aurea recorded from Western Australia is referred to *Litoria* spp., as the range of *L. aurea* does not extend to Western Australia (see Cogger 1992).

Crinia sp. recorded from the Flinders Ranges, South Australia, in the Australian Helminthological Collection (AHC) list are most likely *C. riparia*. A group of these frogs was collected from Warren Gorge, which is within the range of *C. riparia* (Dr Margaret Davies, pers. comm.). A more precise geographical location is, however, required to differentiate *C. riparia* from *C. signifera*, so they must remain *Crinia* sp.

Litoria jervisiensis recorded from South Australia is referred to *L. ewingii* (see Cogger 1992).

Mixophyes sp. collected from the Bunya Mts, Queensland (AHC 6172), could be either *M. fasciolatus* or *M. iteratus*. Examination of the host specimen would be needed to determine the exact species.

Uperoleia marmorata collected from New England National Park, New South Wales (AHC 8055), could be either *U. rugosa* or *U. laevigata*. Davies & Littlejohn (1986) showed both species to be present in this region, while *U. marmorata* was restricted to the north-west of Western Australia. All *U. marmorata* in this checklist are from eastern Australia and helminths from these host specimens are referred to *Uperoleia* spp. Again, examination of the host specimen would be needed to determine which species is correct.

Bufo marinus was introduced to Australia in 1935

from South America (via Hawaii) (Easteal 1981). It is 'naturally' found in Queensland, northern New South Wales and eastern Northern Territory. Any locations recorded out of this range are from laboratory animals acquired from a commercial supplier.

Records of helminths from frogs in New Guinea are included only if that frog species is also found in Australia.

Comments on helminth taxonomy

Helminth nomenclature follows Prudhoe & Bray (1982) for Monogenea, Digenea and Cestoda, the CIH Keys to the Nematode Parasites of Vertebrates (Hartwich 1974; Chabaud 1975*a*, 1975*b*, 1978; Anderson & Bain 1976, 1982; Petter & Quentin 1976; Durette-Desset 1983) and Spencer Jones & Gibson (1987) for the Nematoda, and Amin (1985) for the Acanthocephala.

The taxonomic status of many genera and species infecting amphibians is in need of revision. Generally, original records of helminths are treated as correct, unless it is known to the author that appropriate revision has taken place.

All helminths are recorded in the parasite-host checklist under the current name with any synonyms also listed.

All previous records of lung nematodes from Australian frogs have been referred to *Rhabdias hylae* Johnston & Simpson, 1942, by Ballantyne (1971), a view accepted in this checklist.

Nasir & Diaz (1971) synonymised the Australian representatives of the genus *Mesocoelium* as *M. megaloon* Johnston, 1912, and *M. monas* (Rudolphi, 1819), Teixeira de Freitas, 1958 (*M. microon* Nicoll, 1914, *M. mesembrinum* Johnston, 1912, *M. oligoon* Johnston, 1912). This is not accepted here, pending further work on the genus.

Frogs often serve as an intermediate host for cestodes, being infected with plerocercoids/spargana in the musculature. The identification of this life cycle stage is impossible without knowledge of the definitive host. In other groups (Acanthocephala, Digenea), larval stages are often identifiable.

Explanation of Format

This checklist has been compiled from all published records up to 1992 known to the author, and from lists of museum holdings.

References to Prudhoe & Bray (1982) on microfiche are shown as 'mf' following the page number.

The lists are arranged as follows:

1. Parasite species are arranged systematically. The amphibian hosts are listed for each helminth followed by the state or territory of origin (? denotes the state or territory was not referred to), literature references, and museum collection numbers, where available. The hosts are arranged with the type host first and all others listed alphabetically after.
2. Host species are arranged alphabetically within each family. The helminths from each host species are listed below the host with the phase of development and site of infection recorded, where known.
3. References.

Authors whose names appear frequently are referred to, where appropriate, by initials, as follows:

LMA L. Madeline Angel
MRY May R. Young
PMM Patricia M. Mawson
SJJ Stephen J. Johnston
THJ T. Harvey Johnston

The major helminth parasite groups are referred to by their initials:

M Monogenea
D Digenea
C Cestoda
N Nematoda
A Acanthocephala

Museums and other sources which are referred to as having amphibian parasites in their collection are abbreviated as follows:

AHC Australian Helminthological Collection, (in the South Australian Museum) Adelaide, SA
AM Australian Museum, Sydney, NSW
BM(NH) Natural History Museum, London, England
CAS Institute of Parasitology, Czechoslovak Academy of Sciences, Ceské Budejovice, Czechoslovakia
QM Queensland Museum, Brisbane, Qld
SAM South Australian Museum, Adelaide, SA
SP Personal collection of Ms Sylvie Pichelin, Parasitology Department, University of Queensland, Brisbane, Qld
TM Tasmanian Museum and Art Gallery, Hobart, Tas

State names are abbreviated as follows:

NSW New South Wales
NT Northern Territory
Qld Queensland
SA South Australia, including Kangaroo I. & Pearson I.

Tas	Tasmania, including Bass Strait Islands (King & Flinders)
Vic	Victoria
WA	Western Australia

ORDER AND ARRANGEMENT OF PARASITES AS PRESENTED UNDER EACH HOST

1. Phylum Platyhelminthes

Class Monogenea Carus, 1863
Order Polyopisthocotylea Odhner, 1912

Family POLYSTOMATIDAE Carus, 1863, emended Gamble, 1896
Subfamily Polystomatinae Gamble, 1896

Class Trematoda Rudolphi, 1808
Order Digenea Van Beneden, 1858
Suborder Prosostomata Odhner, 1905

Family PARAMPHISTOMATIDAE Fischoeder, 1901
Subfamily Diplodiscinae Cohn, 1904

Family GORGODERIDAE Looss, 1901

Family ALLOCREADIIDAE Stossich, 1903

Family PLAGIORCHIIDAE Lühe, 1901, emended Ward, 1917
Subfamily Haematoloechinae Teixeira de Freitas & Lent, 1939, emended Yamaguti, 1958

Family TELORCHIIDAE Stunkard, 1924
Subfamily Opisthioglyphinae Dollfus, 1949

Family BRACHYCOELIIDAE Johnston, 1912

Family LECITHODENDRIIDAE Odhner, 1910

Family BRACHYLAIMIDAE Joyeux & Foley, 1930

Family DIPLOSTOMIDAE Poirier, 1886

Family DOLICHOPERIDAE Yamaguti, 1971

Not further identified

Class Cestoidea Rudolphi, 1808
Order Pseudophyllidea Carus, 1863

Family DIPHYLLOBOTHRIIDAE Lühe, 1910

Order Proteocephalidea Mola, 1928

Family PROTEOCEPHALIDAE La Rue, 1911

Order Cyclophyllidea Braun, 1900

Family NEMATOTAENIIDAE Lühe, 1910

Not further identified

2. Phylum Nematoda

Class Secernentea
Order Rhabditida

Superfamily Rhabditoidea
Family RHABDIASIDAE Railliet, 1916

Order Strongylida

Superfamily Trichostrongyloidea
Family MOLINEIDAE (Skrjabin & Schulz, 1937) Durette-Desset & Chabaud, 1977

Order Oxyurida

Superfamily Oxyuroidea
Family PHARYNGODONIDAE Travassos, 1919

Order Ascaridida

Superfamily Cosmocercoidea
Family COSMOCERCIDAE (Railliet, 1916, subfam.) Travassos, 1925

Superfamily Ascaridoidea
Family ASCARIDIDAE Baird, 1853

Order Spirurida

Superfamily Physalopteroidea
Family PHYSALOPTERIDAE (Railliet, 1893, subfam.) Leiper, 1908

Superfamily Habronematoidea
Family HEDRURIDAE Railliet, 1916

Superfamily Filarioidea

Not further identified

3. Phylum Acanthocephala

Class Palaeacanthocephala Meyer, 1931
Order Echinorhynchida Southwell & MacFie, 1925

Family ECHINORHYNCHIDAE Cobbold, 1876

Order Polymorphida Petrochenko, 1956

Family PLAGIORHYNCHIDAE Golvan, 1960

Not further identified

ORDER AND ARRANGEMENT OF HOSTS AS PRESENTED IN HOST-PARASITE CHECKLIST

Class Amphibia
Order Anura

Family MYOBATRACHIDAE
Adelotus
Arerophryne

Assa
Crinia
Geocrinia
Heleioporus
Hyperoleia
Kyarranus
Leptodactylid
Limnodynastes
Metacrinia
Mixophyes
Myobatrachid
Neobatrachus
Paracrinia
Philoria
Pseudophryne
Ranidella
Rheobatrachus
Taudactylus
Uperoleia

Family HYLIDAE
Chiroleptes
Cyclorana
Hyla
Litoria

Family RANIDAE
Rana

Family BUFONIDAE
Bufo

Unidentified Anura

PARASITE-HOST CHECKLIST

1. Phylum Platyhelminthes

Class Monogenea Carus, 1863
Order Polyopisthocotylea Odhner, 1912

Family POLYSTOMATIDAE Carus, 1863, emended Gamble, 1896
Subfamily Polystomatinae Gamble, 1896

Parapolystoma bulliense (Johnston, 1912), Ozaki, 1935
syn. *Polystomum bulliense* Johnston, 1912
Hyla phyllochroa, NSW, SJJ 1912: 297, AM W.346, QM GL 12109, GL 12160, AHC 2200 (wholemount), 2217–2219 (sections)
Hyla lesueurii, NSW, SJJ 1912: 297
Litoria citropa, NSW, AHC 5167
Litoria pearsoniana, Qld, SP

Parapolystoma sp.
Litoria nyakalensis, Qld, SP

Class Trematoda Rudolphi, 1808
Order Digenea Van Beneden, 1858
Suborder Prosostomata Odhner, 1905

Family PARAMPHISTOMATIDAE Fischoeder, 1901
Subfamily Diplodiscinae Cohn, 1904

Diplodiscus megalochrus Johnston, 1912
Hyla aurea, NSW, SJJ 1912: 302, AM W.332, QM GL 11851
Frog, NSW, AHC 3310
Hyla caerulea, Qld, THJ 1916*b*: 60
Limnodynastes peronii, NSW, SJJ 1912: 302
Litoria caerulea, Qld, Prudhoe & Bray 1982: 199 mf

Diplodiscus microchrus Johnston, 1912
Hyla ewingii, NSW, SJJ 1912: 307, AM W.333
Limnodynastes tasmaniensis, NSW, SJJ 1912: 307

Diplodiscus **sp.**
Bufo marinus, Qld, AHC 14, 2978, 3028, 3553, 3563, 3576, 3875
Hyla aurea, NSW, AHC 12683
Hyla caerulea, Qld, QM GL 12350

Amphistome
Bufo marinus, Qld, AHC 4944

Distoma **sp.**
Hyla aurea, ?, MRY 1939: 74

Family GORGODERIDAE Looss, 1901

Gorgodera australiensis Johnston, 1912
Hyla aurea, NSW, SJJ 1912: 326, AM W.340a, AM W. 395, AM W.19850, QM GL 11860, GL 12161
Limnodynastes dorsalis, SA, AHC 3511
Limnodynastes peronii, NSW, SJJ 1912: 326, AM W.340 (this number is given for *H. aurea* in SJJ 1912: 326, but in AM records is for *L. peronii*)

Gorgodera **sp.**
Hyla aurea, NSW, AHC 12680; Vic, AHC 4539; SA, AHC 3529, 3532
Limnodynastes dorsalis, SA, AHC 3498, 3502, 12698
Limnodynastes tasmaniensis, SA, AHC 3489

Family ALLOCREADIIDAE Stossich, 1903

Allocreadiidae sp.
Cyclorana cultripes, Qld, QM GL 11285

Family PLAGIORCHIIDAE Lühe, 1901, emended Ward, 1917
Subfamily Haematoleochinae Teixeira de Freitas & Lent, 1939, emended Yamaguti, 1958

Haematoleochus australis (S.J. Johnston, 1912), Inglis, 1932 syn. *Pneumonoeces australis* S.J. Johnston, 1912
Hyla aurea, NSW, SJJ 1912: 321, AM W.339, W.339a, W.396, W.19849; ?, QM GL 11868, GL 1197

Limnodynastes peronii, NSW, SJJ 1912: 321
Litoria aurea, Tas, AHC 5404
Litoria moorei, WA, Prudhoe & Bray 1982: 83
mf, BM(NH) 1967.10.23.7–9

Family TELORCHIIDAE Stunkard, 1924
Subfamily Opisthioglyphinae Dollfus, 1949

Dolichosaccus anartius (S.J. Johnston, 1912) Yamaguti, 1958
syn. *Brachysaccus anartius* S.J. Johnston, 1912
Hyla aurea, NSW, SJJ 1912: 317, AM W.337, W.398, QM GL 11846, AHC 12685, 12686; ?, QM GL 11868, GL 11997
Limnodynastes peronii, NSW, SJJ 1912:317

Dolichosaccus diamesus S.J. Johnston, 1912
Hyla freycineti, NSW, SJJ 1912: 315, AM W.336, W.19848

Dolichosaccus ischyrus S.J. Johnston, 1912
Limnodynastes dorsalis, NSW, SJJ 1912: 314, AM W.335
Hyla caerulea, NSW, SJJ 1912: 314; Qld, THJ 1916: 60

Dolichosaccus juvenilis (Nicoll, 1918), Travassos, 1930
syn. *Brachysaccus juvenilis* Nicoll, 1918
Chiroleptes brevipalmatus, Qld, Nicoll 1918: 368
Cyclorana cultripes, Qld, QM GL 11280

Dolichosaccus symmetrus (S.J. Johnston, 1912), Yamaguti, 1958
syn. *Brachysaccus symmetrus* Johnston, 1912
Hyla caerulea, NSW, SJJ 1912: 319, AM W.338
Bufo marinus, Qld, AHC 13

Dolichosaccus trypherus S.J. Johnston, 1912
Limnodynastes peronii, NSW, SJJ 1912: 310, AM W.334, QM GL 11850
Hyla aurea, NSW, SJJ 1912: 310, QM GL 11850; SA, AHC 12704
Limnodynastes dorsalis, SA, AHC 12699
Limnodynastes tasmaniensis, SA, AHC 3485, 3487, 3488
Litoria moorei, WA, BM(NH) 1968.4.19.16

***Dolichosaccus* sp.**
syn. *Brachysaccus* sp.
Bufo marinus, Qld, AHC 18, 2973, 2975, 3559, 3874, 4952, 4953, 5192
Hyla aurea, NSW, AHC 3527, 12682
Hyla caerulea, Qld, AHC 12690
Hyla sp., ?, MRY 1939: 75
Limnodynastes dorsalis, SA, AHC 3512, 3513, 12677
Limnodynastes fletcheri, SA, AHC 4583
Limnodynastes tasmaniensis, SA, AHC 3485, 3487, 3488

Family BRACHYCOELIIDAE Johnston, 1912

Mesocoelium megaloon S.J. Johnston, 1912
Hyla ewingii, NSW, SJJ 1912: 335, AM W.343
Litoria caerulea, ?, Freitas 1963: 179 (noted that this specimen should be *M. mesembrinum*)
Litoria ewingii, ?, Prudhoe & Bray 1982:117
mf

Mesocoelium mesembrinum S.J. Johnston, 1912
Hyla caerulea, NSW, SJJ 1912: 330, AM W.341, W.341b, W.393, W.394, AHC 4538
Bufo marinus, Qld, Yuen 1965: 271
Litoria aurea, ?, Prudhoe & Bray 1982: 117
Litoria caerulea, Qld, THJ 1916*b*: 60; NSW, QM GL 11861

Mesocoelium microon Nicoll, 1914
Litoria caerulea, Qld, Nicoll 1914: 339, QM GL 11131
Cyclorana cultripes, Qld, QM GL 11278
Litoria gracilenta, Qld, Nicoll 1914: 339, QM GL 11169

Mesocoelium oligoon S.J. Johnston, 1912
Hyla citropus, NSW, SJJ 1912: 336 AM W.342

***Mesocoelium* sp.**
Bufo marinus, Qld, Freeland et al. 1986: 496, AHC 16, 17, 2967, 2973, 2975, 3138, 3876, 4949, 4951, 4955; SA, AHC 4547 (*Mesocoelium* sp. 2 of LMA)
Hyla caerulea, Qld, AHC 3517–3521, 3523, 3524

Family LECITHODENDRIIDAE Odhner, 1910

Pleurogenoides freycineti (S.J. Johnston, 1912), Travassos, 1930
syn. *Pleurogenes freycineti* Johnston, 1912
Hyla freycineti, NSW, SJJ 1912: 342, AM W.344

Pleurogenoides solus (S.J. Johnston, 1912), Travassos, 1930
syn. *Pleurogenes solus* Johnston, 1912
Hyla aurea, NSW, SJJ 1912: 345, AM W.345, W.19851, W.19852

***Pleurogenes* spp.**
Hyla spp., ?, MRY 1939: 75

Lecithodendriid sp.
Bufo marinus, Qld, Freeland et al. 1986: 496

Family BRACHYLAIMIDAE Joyeux & Foley, 1930

Zeylanurotrema spearei Cribb & Barton, 1991
Bufo marinus, Qld, Cribb & Barton 1991: 207, QM GL 1273, 1274–76, AHC 18984, BM(NH) 1990.12.7.3–5

Family DIPLOSTOMIDAE Poirier, 1886

Fibricola intermedius (Pearson, 1959),

Sudarikov, 1961
syn. *Neodiplostomum intermedium* Pearson, 1959
Hyla pearsoni, ?, diplostomula, Pearson 1961: 135
Hyla caerulea, paratenic host, ?, Pearson 1961: 136
Hyla latopalmata tadpole, ?, Pearson 1961: 135
Leptodactylid sp., ?, Pearson 1961: 135
Mixophyes fasciolatus tadpole, ?, Pearson 1961: 135

Family DOLICHOPERIDAE Yamaguti, 1971

Dolichoperoides macalpini (Nicoll, 1918), Johnston & Angel, 1940
syn. *Dolichopera macalpini* Nicoll, 1918
Limnodynastes sp. tadpole, SA, metacercaria, THJ & Angel 1940: 381, AHC 201320
Hyla aurea raniformis, SA, metacercaria, THJ & Angel 1940: 382
Limnodynastes dorsalis (*dumerili*), SA, metacercaria, THJ & Angel 1940: 382
Limnodynastes tasmaniensis (*platycephalus*), SA, metacercaria, THJ & Angel 1940: 382
Tadpole, SA, metacercaria, AHC 2725

Digenea Not Further Identified

Cercaria ameriannae T.H. Johnston & Beckwith, 1947
Limnodynastes sp., SA, diplostomula, (experimental), THJ & Beckwith 1947: 578, AHC 20219
Tadpole, SA, diplostomula, (experimental), AHC 2272
Cercaria angelae T.H. Johnston & Simpson, 1944
Limnodynastes tasmaniensis tadpole, SA, cysts, AHC 2825; experimental infection of *L. tasmaniensis* tadpoles produced *Tetracotyle* cysts (THJ & Simpson 1944: 131)
Tadpole, SA, metacercaria, AHC 2829, cysts, AHC 2831, 2833
Cercaria ellisi T.H. Johnston & Simpson, 1944
Crinia signifera tadpole, SA, metacercaria, (experimental), THJ & Simpson 1944: 89
Tadpole, SA, cyst, AHC 20206
Cercaria lethargica T.H. Johnston & Muirhead, 1949
Tadpole, SA, AHC 2821
Cercaria natans T.H. Johnston & Muirhead, 1949
Limnodynastes tasmaniensis tadpole, SA, (experimental), THJ & Muirhead, 1949: 104 (belongs to *Echinostomum* group); AHC 12402
***Cercaria* sp.**
Tadpole, SA, (K.I. stylet: experimental), AHC 20260 (Echinostome J: experimental), AHC 20261
(Stylet J.W.: experimental), AHC 20262
Diplostomula
Hyla aurea, SA, AHC 12390
Hyla peronii, SA, AHC 12838
Limnodynastes sp., SA, (experimental), AHC 12398
Limnodynastes tasmaniensis, SA, AHC 4125, 4134, 12702
Echinostome cysts
Frog, SA, AHC 12712
Hyla aurea, SA, AHC 12713
Tadpole, SA, AHC 12387; (experimental), AHC 12722
***Halipegus* sp.**
Litoria caerulea, NT, AHC 5405
Plagiorchid cysts
Hyla aurea, SA, AHC 12388
Strigeid cysts
Hyla aurea, SA, AHC 12384, 12386, 12394
Limnodynastes tasmaniensis, SA; AHC 12380
***Tetracotyle* cysts**
Hyla aurea, SA, AHC 12382
Digenea cysts
Bufo marinus, Qld, cysts, Freeland et al. 1986: 494
Frog, NSW, cysts, AHC 12393
Hyla aurea, NSW, cysts, AHC 12372, 12373, 12390, 12392, 12718–12721
Hyla peroni, SA, cysts, AHC 12401
Limnodynastes dorsalis, SA, cysts, AHC 12369, 12385, 12400, 12406, 12407
Limnodynastes tasmaniensis, SA, cysts, AHC 12370, 12371, 12389, 12395, 12397, 12399, 12406, 12407
Tadpole, SA, cysts, AHC 12375–12377, 12403; (experimental), AHC 12379
Digenea
Bufo marinus, Qld, Freeland et al. 1986: 496; Qld, AHC 15, 19, 2004, 2969, 2971, 2977, 3145, 3157, 3309, 3313, 3535–3552, 3555–3558, 3561, 3562, 3564–3575, 3577–3580, 3880, 3947, 4077, 4078, 4099, 4101, 4215, 4351, 4889, 5020, 5021
Hyla aurea, NSW, AHC 12687, 12681, 4546, 4537, 4536, 4535; SA, AHC 3520, 4083, 4341, 4579, 12688
Hyla peroni, SA, AHC 12396
Limnodynastes dorsalis, SA, AHC 3494–3497, 3499–3501, 3504–3510, 4545, 4548–4550, 12676, 12700
Limnodynastes fletcheri, SA, AHC 12678
Limnodynastes sp., SA, AHC 3478–3480, 3482, 3483
Limnodynastes tasmaniensis, SA, AHC 1877, 3484
Litoria caerulea, Qld, AHC 3522, 3525, 3526, 12691; NT, AHC 4544

Litoria dahlii, NT, AHC 6809, 6993
Litoria moorei, WA, AHC 8545
Litoria rothii, Qld, AHC 7181
Rheobatrachus silus, Qld, AHC 6232
Taudactylus diurnus, Qld, AHC 8237

Class Cestoidea Rudolphi, 1808
Order Pseudophyllidea Carus, 1863

Family DIPHYLLOBOTHRIIDAE Lühe, 1910

?*Ligula* sp.
Hyla aurea, NSW, larval stage, Haswell 1890: 661 (recorded as having possible affinities with *Ligula*)
Hyla caerulea, Qld, AHC 2350–2352
Spirometra erinacei Rudolphi, 1819
Litoria rubella, NT, AHC 17857
Diphyllobothriidae spargana
(*?Diphyllobothrium* (=*Spirometra*) *erinacei* (Rudolphi, 1819))
Bufo marinus, Qld, AHC 4100
Hyla aurea, NSW, WA, THJ 1912: 70
Hyla caerulea, Qld, NSW, THJ 1912: 70
Hyla latopalmata, ?, (experimental), Sandars 1953: 67
Hyla latopalmata tadpole, ?, (experimental), Sandars 1953: 67
? *Spirometra mansoni* (Cobbold, 1882), Stiles & Taylor, 1902 *Bufo marinus*, spargana, Bennett 1978: 756

Order Proteocephalidea Mola, 1928

Family PROTEOCEPHALIDAE La Rue, 1911

***Ophiotaenia* sp.**
Hyla aurea, ?, SJJ 1914: 44; SA, AHC 2825
Proteocephalus hylae (S.J. Johnston, 1912), Prudhoe & Bray, 1982
syn. *Ophiotaenia hylae* S.J. Johnston, 1912
Hyla aurea, NSW, THJ 1912: 63
Litoria aurea, NSW, QM G 423
Litoria moorei, WA, BM(NH) 1968.4.19.1–5; AHC 8178
Proteocephalid plerocercoids
Bufo marinus, Qld, Freeland et al. 1986: 496
Crinia laevis, Tas, Hickman 1960: 20
Crinia signifera, Tas, Hickman 1960: 20
Hyla aurea, Vic, AHC 2327; SA, AHC 8696
Limnodynastes peronii, Tas, Hickman 1960: 20

Order Cyclophyllidea Braun, 1900

Family NEMATOTAENIIDAE Lühe, 1910

Cylindrotaenia criniae (Hickman, 1960), Jones, 1987
syn. *Baerietta criniae criniae* Hickman, 1960
Crinia tasmaniensis, Tas, Hickman 1960: 18, TM K710–712
Ranidella tasmaniensis, Tas, Jones 1987: 207
Cylindrotaenia minor (Hickman, 1960), Jones, 1987
syn. *Barietta criniae minor* Hickman, 1960
Crinia tasmaniensis, Tas, Hickman 1960: 18
Crinia laevis, Tas, Hickman 1969: 18
Crinia signifera, Tas, Hickman 1960: 18; TM K716–717
Ranidella tasmaniensis, Tas, Jones 1987: 211
Assa darlingtoni, NSW, Jones 1987: 212, QM GL 4887; Qld, Jones & Delvinquier 1991: 492
Geocrinia laevis, Tas, Jones 1987: 211
Philoria loveridgei, Qld, Jones & Delvinquier 1991: 492
Ranidella signifera, Tas, Jones 1987: 211
Nematotaenia hylae Hickman, 1960
Hyla ewingii, Tas, Hickman 1960: 8, TM K705, K707–709
Litoria ewingii, Tas, Jones 1987: 184, 185
Bufo marinus, Qld, Jones & Delvinquier 1991: 492
Crinia signifera, Tas, Hickman 1960: 8, TM K706
Cyclorana novaehollandiae, Qld, Jones & Delvinquier 1991: 492
Limnodynastes ornatus, Qld, Jones & Delvinquier 1991: 492
Litoria fallax, Qld, Jones 1987: 185
Litoria inermis, Qld, Jones 1987: 185
Litoria latopalmata, Qld, Jones 1987: 185, QM GL 4886
Litoria pallida, Qld, Jones & Delvinquier 1991: 492
Litoria peronii, Qld, Jones & Delvinquier 1991: 492
Ranidella parinsignifera, Qld, Jones 1987: 185, QM GL 4887
Ranidella signifera, Tas, Jones 1987: 184, 185
Ranidella riparia, SA, Jones & Delvinquier 1991: 492
Uperoleia rugosa, Qld, Jones & Delvinquier 1991: 492
***Nematotaenia* sp.**
Hyla caerulea, ?, MRY 1939: 74; NSW, THJ 1916*a*: 195, Prudhoe & Bray 1982:12 mf
Hyla freycineti, ?, MRY 1939: 75; NSW, THJ 1916*a*: 194, Prudhoe & Bray 1982:12 mf
Hyperoleia marmorata, ?, MRY 1939: 75; NSW, THJ 1916*a*: 194, Prudhoe & Bray 1982: 12 mf
Triplotaenia mirabilis Boas, 1902
Hyla aurea, ?, MRY 1939: 74 (usually a cestode of marsupials; see Prudhoe & Bray 1982:3 mf for discussion)

Cestoda Not Further Identified

Bufo marinus, Qld, AHC 10, 46, 4892
Crinia signifera, SA, AHC 4419, 4424, 20687
Crinia sp., SA, AHC 4234
Hyla aurea, NSW, SJJ 1912: 291; Vic, AHC 2326; SA, larva, AHC 4584
Hyla caerulea, NSW, SJJ 1912: 290; Qld, AHC 1223
Hyla ewingi, NSW, AHC 4082; SA, AHC 4304, 4369
Hyla ewingi alpina, NSW, AHC 4079–4081
Hyla freycineti, NSW, SJJ 1912: 291
***Hyla* sp.**, SA, AHC 40
Hyperoleia marmorata, NSW, SJJ 1912: 290
***Limnodynastes* sp.**, Qld, AHC 2376; SA, AHC 2378
Metacrinia nichollsi, WA, AHC 48
Rheobatrachus silus, Qld, AHC 8913
Frog, SA, AHC 20678

2. Phylum Nematoda

Class Secernentea
Order Rhabditida

Superfamily Rhabditoidea
Family RHABDIASIDAE Railliet, 1916

Rhabdias australiensis Moravec & Sey, 1990
Rana daemeli, Qld, Moravec & Sey 1990: 283, CAS N–450
Rhabdias hylae Johnston & Simpson, 1942
Hyla aurea, NSW, THJ & Simpson 1942: 176, SJJ 1912: 291 (lung nematode); VIC, THJ & Simpson 1942: 176; SA, Ballantyne 1971: 51
Adelotus brevis, Qld, Ballantyne 1971: 51
Crinia georgiana, WA, Ballantyne 1971: 51
Crinia glauerti, WA, Ballantyne 1971: 51
Crinia insignifera, WA, Ballantyne 1971: 51
Crinia leai, WA, Ballantyne 1971: 51
Crinia signifera, NSW, SA, Ballantyne 1971: 50
Crinia subinsignifera, WA, Ballantyne 1971: 51
Crinia victoriana, Vic, Ballantyne 1971: 50
Hyla aurea raniformis, Vic, Ballantyne 1971: 50
Hyla caerulea, QLD, THJ & Simpson 1942: 176
Hyla latopalmata, Qld, Ballantyne 1971: 51
Hyla lesueuri, Qld, Ballantyne 1971: 51
Hyla peroni, NSW, SJJ 1912: 290 (lung nematode); THJ & Simpson 1942: 178
Limnodynastes dorsalis, NSW, THJ & Simpson 1942: 179
Limnodynastes fletcheri, Qld, Ballantyne 1971: 51
Limnodynastes peroni, NSW, SJJ 1912: 290 (lung nematode); THJ & Simpson 1942: 179; Qld, Ballantyne 1971: 51; SA, Ballantyne 1971: 51
Limnodynastes tasmaniensis, NSW, SJJ 1912: 290 (lung nematode), THJ & Simpson 1942: 176; SA, THJ & Simpson 1942: 176, Ballantyne 1971: 50; Vic, Ballantyne 1971: 50
Mixophyes fasciolatus, Qld, Ballantyne 1971: 51
Pseudophryne bibronii, NSW, Ballantyne 1971: 50
Pseudophryne guentheri, WA, Ballantyne 1971: 51
Pseudophryne occidentalis, WA, Ballantyne 1971: 51
Pseudophryne sp., SA, Ballantyne 1971: 51
Rhabdias nigrovenosum (Goeze, 1800)
syn. *Rhabdonema nigrovenosum* Goeze, 1800; listed as a synonym of *Rhabdias bufonis* (Schrank, 1788) in Yamaguti 1961: 84
Hyla aurea, ?, AM W.19853–6
***Rhabdias* sp.**
Hyla aurea, NSW, VIC, THJ & Simpson 1942: 178 (referring to THJ 1938: 151); WA, BM(NH) 1989.1987–1988
Hyla moorei, WA, BM(NH) 1980.263–282
***Rhabdonema* sp.**
Hyla aurea, NSW, Vic, THJ & Simpson 1942: 178 (referring to Haswell 1891)
Hyla caerulea, QLD, THJ 1916*b*: 60

Order Strongylida

Superfamily Trichostrongyloidea
Family MOLINEIDAE (Skrjabin & Schulz, 1937) Durette-Desset & Chabaud, 1977

Oswaldocruzia* (*O.*) *limnodynastes T.H. Johnston & Simpson, 1942
Limnodynastes dorsalis, SA, THJ & Simpson 1942: 172; THJ & PMM 1949: 65
Hyla aurea, NSW, Vic, THJ & Simpson 1942: 172
Hyla peroni, SA, THJ & PMM 1949: 65

Order Oxyurida

Superfamily Oxyuroidea
Family PHARYNGODONIDAE Travassos, 1919

Parathelandros australiensis (Johnston & Simpson, 1942), Inglis, 1968
syn. *Cosmocerca australiensis* Johnston & Simpson, 1942
Limnodynastes dorsalis, SA, THJ & Simpson 1942: 176
Limnodynastes fletcheri, SA, Inglis 1968: 173
Parathelandros carinae Inglis, 1968

Heleioporus albopunctatus, WA, Inglis 1968: 176
Heleioporus australiacus, WA, Inglis 1968: 176
Heleioporus eyrei, WA, Inglis 1968: 176
Heleioporus psammophilus, WA, Inglis 1968: 176
Neobatrachus pelobatoides, WA, Inglis 1968: 176

Parathelandros johnstoni Inglis, 1968
Heleioporus eyrei, WA, Inglis 1968: 175
Limnodynastes dorsalis, WA, Inglis 1968: 175
Neobatrachus centralis, WA, Inglis 1968: 175 (specimens in poor condition, may be *P. maini* or *P. limnodynastes*)
Neobatrachus pelobatoides, WA, Inglis 1968: 175

Parathelandros limnodynastes (Johnston & Mawson, 1942), Inglis, 1968
syn. *Pharyngodon limnodynastes* Johnston & Mawson, 1942
Limnodynastes dorsalis, SA, THJ & PMM 1942: 94; Inglis 1968: 175
Limnodynastes dorsalis dumerili, SA, THJ & PMM 1942: 94

Parathelandros maini Inglis, 1968
Hyla moorei, WA, Inglis 1968: 176
Hyla adelaidensis, WA, Inglis 1968: 176
Hyla cyclorhyncha, WA, Inglis 1968: 176

Parathelandros mastigurus Baylis, 1930
Hyla caerulea, Qld, Baylis 1930: 359, Inglis 1968: 173; NSW, Inglis 1968: 173
Bufo marinus, Qld, Inglis 1968: 173
Hyla gracilenta, Qld, Baylis 1930: 359
Hyla gracilis, Qld, Inglis 1968: 173 (refers to *Hyla gracilenta* recorded by Baylis 1930)

Parathelandros propinqua (Johnston & Simpson, 1942), Inglis, 1968
syn. *Cosmocerca propinqua* Johnston & Simpson, 1942
Limnodynastes dorsalis, SA, THJ & Simpson 1942: 176

***Parathelandros* spp.**
Bufo marinus, Qld, Freeland et al. 1986: 496
Hyla aurea, WA, (female only), BM(NH) 1980.283–292
Hyla rubella, WA, (female only), BM(NH) 1980.318–317
Oxyurids Not Further Identified
Bufo marinus, Qld, AHC 2276, 4950; Vic, AHC 9048, 9059
Cyclorana sp., NT, AHC 4450
Hyla aurea, Vic, AHC 2311
Hyla caerulea, Qld, AHC 2343; NT, AHC 4947
Limnodynastes dorsalis, SA, AHC 2306, 3176
Limnodynastes tasmaniensis, SA, AHC 1417, 5030
Litoria rothii, Qld, AHC 7156
Litoria rubella, Qld, AHC 7180
Mixophyes sp., Qld, AHC 6172

Order Ascaridida

Superfamily Cosmocercoidea
Family COSMOCERCIDAE (Railliet, 1916 subfam.) Travassos, 1925

Cosmocerca limnodynastes Johnston & Simpson, 1942
Limnodynastes dorsalis, SA, THJ & Simpson 1942: 174

Cosmocercinae gen. sp. 1
Rana daemeli, Qld, Moravec & Sey 1990: 273

Austraplectana kartanum (Johnston & Mawson, 1941), Baker, 1981
syn. *Rallietnema kartanum* Johnston & Mawson, 1941
Hyla jervisiensis, SA, THJ & PMM 1941: 146
Heleioporus eyrei, WA, Inglis 1968: 166
Hyla moorei, WA, Inglis 1968: 166, BM(NH) 1967. 1158–1159
Litoria nasuta, Qld, Baker 1981: 111
Austraplectana sp.
Frog, Qld, Baker 1981: 116

Maxvachonia adamsoni Moravec & Sey, 1990
Litoria infrafrenata, New Guinea, Moravec & Sey 1990: 276, CAS N–449

Maxvachonia ewersi Mawson, 1972
Litoria nasuta, New Guinea, PMM 1972: 105

Maxvachonia flindersi (Johnston & Mawson, 1941), Mawson, 1972
syn. *Aplectana flindersi* Johnston & Mawson, 1941; *Austracerca flindersi* (Johnston & Mawson, 1941) Inglis 1968
Hyla jervisiensis, SA, THJ & PMM 1941: 148
Bufo marinus, Qld, PMM 1972: 104, AHC 5170
Heleioporus australiacus, WA, Inglis 1968: 165
Heleioporus barycragus, WA, PMM 1972: 104
Heleioporus inornatus, WA, PMM 1972: 104, AHC 5180
Heleioporus psammophilis, WA, Inglis 1968: 165
Hyla cyclorhyncha, WA, Inglis 1968: 165
Limnodynastes dorsalis, SA, PMM 1972: 104, AHC 5183
Litoria adelaidensis, WA, PMM 1972: 104, AHC 5172
Litoria caerulea, NT, PMM 1972: 104, AHC 5182
Litoria moorei, WA, PMM 1972: 104, AHC 5175

Falcaustra hylae (Johnston & Simpson, 1942), Chabaud & Golvan, 1957

syn. *Spironoura hylae* Johnston & Simpson, 1942
Hyla aurea, NSW, THJ & Simpson 1942: 173
Cosmocercoid
Bufo marinus, Qld, AHC 5009

Superfamily Ascaridoidea
Family ASCARIDIDAE Baird, 1853

Ophidascaris pyrrhus Johnston & Mawson, 1942
Tadpole, Qld, (experimental infection), QM GL 9107
Frog, Qld, QM GZ 15
Raillietascaris varani (Baylis & Daubney, 1922), Sprent, 1985
Tadpole, ?, QM GL 5674
Seuratascaris numidica (Seurat, 1917), Sprent, 1985
Rana daemeli, Qld, Sprent 1985: 241

Order Spirurida

Superfamily Physalopteroidea
Family PHYSALOPTERIDAE (Railliet, 1893 subfam.) Leiper, 1908

Pseudorictularia disparilis (Irwin-Smith, 1922), Dollfus & Desportes, 1945
syn. *Rictularia disparilis* Irwin-Smith, 1922
Litoria inermis, Qld, Owen & Moorhouse 1980: 1014
Litoria nigrofrenata, Qld, Owen & Moorhouse 1980: 1014
Rana daemeli, Qld, Owen & Moorhouse 1980: 1013
Physaloptera confusa T.H. Johnston & Mawson, 1942
Limnodynastes tasmaniensis, NSW, encysted larva, THJ & Simpson 1942: 178; SA, encysted larva, THJ & PMM 1949:69
Hyla aurea, NSW, encysted larva, THJ & PMM 1942: 91; THJ & Simpson 1942: 178
Hyla caerulea, Qld, encysted larva, THJ & Simpson 1942: 178
Hyla peroni, SA, encysted larva, THJ & PMM 1942: 91; THJ & PMM 1949: 69; THJ & Simpson 1942: 178
Limnodynastes dorsalis, SA, encysted larva, THJ & PMM 1942: 91; NSW, encysted larva, THJ & Simpson 1942: 178
Limnodynastes dorsalis dumerilii, SA, encysted larva, THJ & PMM 1942: 91; THJ & Simpson 1942: 178
***Physaloptera* sp.**
Cyclorana australis, WA, larva AHC 6399
Heleioporus eyrei, WA, AHC 3012
Hyla aurea, SA, AHC 12386
Limnodynastes dorsalis dumerilii, SA, cysts, AHC 2356 (frog taken from intestine of tiger snake, *Notechis scutatus*), 2375

Superfamily Habronematoidea
Family HEDRURIDAE Railliet, 1916

Hedruris hylae Johnston & Mawson, 1941
Hyla jervisiensis, SA, THJ & PMM 1941: 148
***Hedruris* sp.**
Crinia signifera, SA, AHC 28

Superfamily Filarioidea
Filarioidea ?gen. ?sp.

Filaria cochleata Railliet, 1916
syn. *Filaria spiralis* Oerley, 1882
Heleioporus albopunctatus, ?, Oerley 1882: 312

Nematoda Not Further Identified

***Agamonema* sp.**
Hyla caerulea, Qld, encysted larva, THJ 1914: 82
Dorylaimid
Frog, SA, AHC 6417
Nematode larvae
Bufo marinus, Qld, cysts, Freeland et al. 1986: 496
Hyla moorei, WA, BM(NH) 1980.298–307
Arenophryne rotunda, WA, cysts, AHC 6808
Hyla caerulea, Qld, cysts, AHC 2341
Nematodes
Bufo marinus, Qld, Freeland et al. 1986: 496, AHC 8,9, 2974, 3258
Crinia georgiana, WA, AHC 8081, 8079
Crinia glauerti, WA, AHC 8119, 8113
Crinia haswelli, Vic, AHC 8084
Crinia leai, WA, AHC 8115, 8082, 8078
Crinia pseudinsignifera, WA, AHC 8118, 8114
Crinia riparia, SA, AHC 8077
Crinia rosea, WA, AHC 8076
Crinia signifera, NSW, SJJ 1912:290; SA, AHC 20, 22–24, 3617, 6799, 8102, 8105; Vic, AHC 1083, 1098; NSW, AHC 8066
Crinia sp., Vic, AHC 21; SA, AHC 4210, 4211, 4214, 4217, 4219, 4231–4233
Crinia subinsignifera, WA, AHC 8080, 8075
Crinia victoriana, Vic, AHC 8122, 8069, 8070, 8088, 8096, 8099
Cyclorana australis, WA, AHC 12880
Heleioporus eryei, WA, AHC 8120
Hyla adelaidensis, NSW, AHC 1760
Hyla aurea, NSW, SJJ 1912: 291, AHC 3528, 2306, 2308, 2309, 2314–2316, 2318–2321, 2323, 2324; SA, AHC 3520
Hyla aurea raniformis, Vic, AHC 8094
Hyla caerulea, NSW, SJJ 1912: 290, AHC 2339, 2337, 2336, 2333, 2360; NT, AHC 2331; Qld, AHC 2349, 2346, 2344, 2342, 2340, 2338, 2335, 2235
Hyla dentata, NSW, SJJ 1912: 291

Hyla ewingii, NSW, SJJ 1912: 291; SA, AHC 8236
Hyla jervisiensis, SA, AHC 1759, 3615
Hyla lesueurii, NSW, SJJ 1912: 291; Qld, AHC 8238
Hyla peronii, NSW, SJJ 1912: 290; SA, AHC 12396
Hyla phyllochroa, NSW, SJJ 1912: 290
Kyarranus sphagnicolus, NSW, AHC 8247
Limnodynastes dorsalis, NSW, SJJ 1912: 290, AHC 2365, 3362, 2361, 2360; Vic, AHC 8068; Qld, AHC 2367; SA, AHC 2368, 3010, 3176, 8108, 8235
Limnodynastes fletcheri, NSW, AHC 8059
Limnodynastes peronii, NSW, SJJ 1912: 290, AHC 1728, 3477; SA, AHC 8103
Limnodynastes sp., Qld, AHC 2605
Limnodynastes tasmaniensis, NSW, SJJ 1912: 290, AHC 8064; Vic, AHC 36, 8087, 8100; SA, AHC 25, 26, 39, 1877, 1882, 3320, 3619, 3622, 5031, 8101, 8107, 8110, 12389
Litoria aurea, SA, AHC 8073
Litoria booroolongensis, NSW, AHC 8063
Litoria caerulea, Qld, AHC 8061, 8060
Litoria dahlii, NT, AHC 6809, 6993
Litoria ewingii, Vic, AHC 8071, 8072, 8095, 8097
Litoria nigrofrenata, Qld, AHC 6145
Litoria rothii, Qld, AHC 7181
Litoria verreauxii, NSW, AHC 8085
Mixophyes fasciolatus, Qld, AHC 8093, 8056
Neobatrachus pelobatoides, WA, AHC 8121, 8116
Neobatrachus pictus, SA, AHC 8104
Pseudophryne bibronii, Vic, AHC 8090; NSW, AHC 8062; SA, AHC 4213, 4218, 4220–4227, 8089, 8106, 8111
Pseudophryne guentheri, WA, AHC 8117, 8074
Pseudophryne occidentalis, WA, AHC 8112
Pseudophryne semimarmorata, SA, AHC 8109
Uperoleia marmorata, NSW, AHC 8055

3. Phylum Acanthocephala

Class Palaeacanthocephala Meyer, 1931
Order Echinorhynchida Southwell & MacFie, 1925

Family ECHINORHYNCHIDAE Cobbold, 1876

Acanthocephalus criniae Snow, 1971
Crinia tasmaniensis, Tas, Snow 1971: 147, TM K228–230, AHC 18165
Crinia laevis, Tas, Snow 1971: 147
Crinia signifera, Tas, Snow 1971: 147
Pseudoacanthocephalus perthensis Edmonds, 1971
Litoria moorei, WA, Edmonds 1971: 55; AHC 5048, 5051
Limnodynastes dorsalis, WA, Edmonds 1971: 55

Order Polymorphida

Family PLAGIORHYNCHIDAE Golvan, 1960

Porrorchis hylae (Johnston, 1914), Schmidt & Kuntz, 1967
syn. *Echinorhynchus* sp. Johnston, 1912; *Echinorhynchus hylae* Johnston, 1914; *Echinorhynchus bulbocaudatus* Southwell & MacFie, 1925; *Gordiorhynchus hylae* (Johnston, 1914), Johnston & Edmonds, 1948; *Pseudoporrorchis hylae* (Johnston, 1914), Edmonds, 1957
Limnodynastes dorsalis, SA, encysted larva, THJ & Edmonds 1948: 69
Bufo marinus, Qld, encysted larva, Freeland et al. 1986: 496 (identified by Edmonds 1989: 130)
Hyla aurea, NSW, encysted larva, THJ 1912: 84, THJ 1914: 83; SA, NSW, THJ & Edmonds 1948: 69
Hyla caerulea, Qld, encysted larva, THJ 1914: 83, THJ & Edmonds 1948:69

Acanthocephala Not Further Identified

***Acanthocephala* sp.**
Hyla caerulea, NSW, QM GL 12287
Hyla peronii, Qld, QM GL 12346
Acanthocephala
Limnodynastes sp., SA, AHC 3409; larva, AHC 3481

Host - parasite checklist

Order Anura

Family MYOBATRACHIDAE

Adelotus brevis (Günther, 1863)
N *Rhabdias hylae*, (lung)
Arerophryne rotunda Tyler, 1976
N Nematode larva, cysts
Assa darlingtoni (Loveridge, 1933)
C *Cylindrotaenia minor*, (intestine)
Crinia georgiana Tschudi, 1838
N *Rhabdias hylae*, (lung)
N Nematodes, (duodenum, rectum)
Crinia glauerti Loveridge, 1933
N *Rhabdias hylae*, (lung)
N Nematodes, (buccal cavity, rectum, ileum)
Crinia haswelli Fletcher, 1894
see *Paracrinia haswelli*

Crinia insignifera Moore, 1954
N *Rhabdias hylae*, (lung)

Crinia laevis Günther, 1864
see *Geocrinia laevis*

Crinia leai Fletcher, 1898
see *Geocrinia leai*

Crinia parinsignifera Main, 1957
C *Nematotaenia hylae*, (intestine)

Crinia pseudinsignifera Main, 1957
N Nematodes, (ileum)

Crinia riparia Littlejohn & Martin, 1965
C *Nematotaenia hylae*, (intestine)
N Nematodes, (rectum)

Crinia rosea Harrison, 1927
see *Geocrinia rosea*

Crinia signifera (Girard, 1853)
C proteocephalid plerocercoids, (mesentery & under skin)
C *Cylindrotaenia minor*, (duodenum, ileum)
C *Nematotaenia hylae*, (duodenum)
C Cestodes, (small intestine)
N *Rhabdias hylae*, (lung)
N *Hedruris* sp., (stomach)
N Nematodes, (stomach, intestine, buccal cavity, rectum, lung, abdominal cavity)
A *Acanthocephalus criniae*, (duodenum, ileum)

Crinia signifera (Girard, 1853) tadpole
D *Cercaria ellisi*, metacercaria, (kidney, mesenteries, heart lung), (experimental)

Crinia subinsignifera Littlejohn, 1957
N *Rhabdias hylae*, (lung)
N Nematodes, (rectum)

Crinia tasmaniensis (Günther, 1864)
C *Cylindrotaenia criniae*, (duodenum, ileum)
C *Cylindrotaenia minor*, (duodenum, ileum)
A *Acanthocephalus criniae*, (duodenum, ileum)

Crinia victoriana Boulenger, 1888
see *Geocrinia victoriana*

***Crinia* sp.**
C Cestodes, (intestine)
N Nematodes, (intestine, stomach, rectum)

Geocrinia laevis (Günther, 1864)
C proteocephalid plerocercoids, (mesentery)
C *Cylindrotaenia minor*, (duodenum, ileum)
A *Acanthocephalus criniae*, (duodenum, ileum)

Geocrinia leai (Fletcher, 1898)
N *Rhabdias hylae*, (lung)
N Nematodes, (abdominal cavity, duodenum)

Geocrinia rosea (Harrison, 1927)
N Nematodes, (rectum)

Geocrinia victoriana (Boulenger, 1888)
N *Rhabdias hylae*, (lung)
N Nematodes, (duodenum, rectum)

Heleioporus albopunctatus Gray, 1841
N *Parathelandros carinae*, (rectum)
N *Filaria cochleata*, (encapsulated between serous and muscular layers of stomach)

Heleioporus australiacus (Shaw & Nodder, 1795)
N *Parathelandros carinae*, (rectum)
N *Maxvachonia flindersi*, (rectum)

Heleioporus barycragus Lee, 1967
N *Maxvachonia flindersi*

Heleioporus eyrei (Gray, 1845)
N *Parathelandros carinae*, (rectum)
N *Parathelandros johnstoni*, (rectum)
N *Austraplectana kartanum*, (rectum)
N *Physaloptera* sp., (stomach)
Nematodes, (stomach)

Heleioporus inornatus (Lee & Main, 1954)
N *Maxvachonia flindersi*, (rectum)

Heleioporus psammophilus (Lee & Main, 1954)
N *Parathelandros carinae*, (rectum)
N *Maxvachonia flindersi*, (rectum)

Hyperolia marmorata (Gray, 1841)
see *Uperoleia* spp.

Kyarranus loveridgei (Parker, 1940)
C *Cylindrotaenia minor*, (intestine)

Kyarranus sphagnicolus Moore, 1958
N Nematodes, (rectum)

Leptodactylid sp.
see Myobatrachid sp.

Limnodynastes dorsalis (Gray, 1841)
for *Limnodynastes dorsalis* from any state, except WA, see *Limnodynastes dumerilii*
N *Parathelandros johnstoni*, (rectum)
A *Pseudoacanthocephalus perthensis*, (intestine)

Limnodynastes dorsalis dumerilii
see *Limnodynastes dumerilii*

Limnodynastes dumerilii Peters, 1863
D *Gorgodera australiensis*
D *Gorgodera* sp.
D *Dolichosaccus ischyrus*, (intestine)
D *Dolichosaccus trypherus*
D *Dolichosaccus* sp.
D *Dolichoperoides macalpini*, metacercaria, (tissues)
D Digenea cysts
D Digenea, (intestine, stomach)
N *Rhabdias hylae*, (lung)
N *Oswaldocruzia limnodynastes*, (intestine)
N *Parathelandros australiensis*, (rectum, intestine)
N *Parathelandros limnodynastes*
N *Parathelandros propinqua*, (rectum, intestine)
N Oxyurid
N *Cosmocerca limnodynastes*
N *Maxvachonia flindersi*, (rectum)
N *Physaloptera confusa*, encysted larva, (mesentery, stomach, peritoneum)
N *Physloptera* sp., cysts

N Nematodes, (stomach, intestine, rectum)
A *Porrorchis hylae*, encysted larva, (mesenteries)

Limnodynastes fletcheri Boulenger, 1888
D *Dolichosaccus* sp.
D Digenea
N *Rhabdias hylae*, (lung)
N *Parathelandros australiensis*, (rectum)
N Nematodes, (duodenum, rectum)

Limnodynastes ornatus (Gray, 1842)
C *Nematotaenia hylae*, (intestine)

Limnodynastes peronii (Duméril & Bibron, 1841)
D *Diplodiscus megalochrus*, (rectum)
D *Gorgodera australiensis*, (bladder)
D *Dolichosaccus anartius*, (intestine, rectum)
D *Dolichosaccus trypherus*, (duodenum)
D *Haematoleochus australis*, (lungs)
C proteocephalid plerocercoids, (mesentery)
N *Rhabdias hylae*, (lungs)
N Nematodes, (lungs, intestine, rectum, stomach)

Limnodynastes tasmaniensis Günther, 1858
D *Diplodiscus microchrus*, (rectum)
D *Gorgodera* sp.
D *Dolichosaccus trypherus*, (intestine)
D *Dolichosaccus* sp.
D *Dolichoperoides macalpini*, metacercaria (tissues)
D Diplostomula, (buccal cavity)
D Strigeid, cysts
D Digenea cysts, (muscles, subcutaneous)
D Digenea, (gut)
N *Rhabdias hylae*, (lung)
N Oxyurids, (abdominal cavity)
N *Physaloptera confusa*, encysted larva, (stomach, peritoneum)
N Nematodes, (lungs, stomach, intestine, rectum)

Limnodynastes tasmaniensis Günther, 1858 tadpole
D *Cercaria angelae*, cysts, (wall of thorax and rectum, pericardium, tail tissue, base of forleg), (experimental)
D *Cercaria natans*, (kidney tissue, kidney peritoneum), (experimental)

Limnodynastes tasmaniensis (platycephalus) Günther, 1867
see *Limnodynastes tasmaniensis*

***Limnodynastes* sp.**
D Diplostomula, (eye), (experimental)
D Digenea, (stomach, intestine, rectum)
C Cestodes, (coelom)
N Nematodes, (stomach)
A Acanthocephala, (mesentery)
A Acanthocephala, larva, (rectum)

***Limnodynastes* sp. tadpole**
D *Cercaria amerianna*, diplostomula, (tissues), (experimental)
D *Dolichoperoides macalpini*, metacercaria, (tissues)

Metacrinia nichollsi (Harrison, 1927)
C Cestodes

Mixophyes fasciolatus Günther, 1864
N *Rhabdias hylae*, (lung)
N Nematodes, (rectum)

Mixophyes fasciolatus Günther, 1864 tadpole
D *Fibricola intermedius*, metacercaria, (muscles)

***Mixophyes* sp.**
N Oxyurid

Myobatrachid sp.
D *Fibricola intermedius*, metacercaria, (muscle)

Neobatrachus centralis (Parker, 1940)
N *Parathelandros johnstoni*, (rectum)

Neobatrachus pelobatoides (Werner, 1914)
N *Parathelandros carinae*, (rectum)
N *Parathelandros johnstoni*, (rectum)
N Nematodes, (rectum)

Neobatrachus pictus Peters, 1863
N Nematodes, (rectum)

Paracrinia haswelli (Fletcher, 1894)
N Nematodes, (duodenum, rectum)

Philoria loveridgei Parker, 1940
see *Kyarranus loveridgei*

Pseudophryne bibronii Günther, 1858
N *Rhabdias hylae*, (lung)
N Nematodes, (duodenum, rectum, stomach)

Pseudophryne guentheri Boulenger, 1964
N *Rhabdias hylae*, (lung)
N Nematodes, (rectum)

Pseudophryne occidentalis Parker, 1940
N *Rhabdias hylae*, (lung)
N Nematodes, (rectum, stomach)

Pseudophryne semimarmorata Lucas, 1892
N Nematodes, (rectum)

***Pseudophryne* sp.**
N *Rhabdias hylae*, (lung)

***Ranidella* spp.**
for all *Ranidella* species, see the *Crinia* equivalent

Rheobatrachus silus Liem, 1973
D Digenea, (rectum)
C Cestodes

Taudactylus diurnus Straughan & Lee, 1966
D Digenea, (rectum)

Uperoleia marmorata Gray, 1841
for *Uperoleia marmorata* from all states, except WA, see *Uperoleia* spp.

Uperoleia rugosa (Andersson, 1916)
C *Nematotaenia hylae*, (intestine)

***Uperoleia* spp.**
C *Nematotaenia* sp.
C Cestodes, (small intestine)
N Nematodes, (rectum)

Family HYLIDAE

Chiroleptes brevipalmatus Peters, 1871
see *Cyclorana brevipes*

Cyclorana australis (Gray, 1842)
N *Physaloptera* sp., larva, (buccal cavity)
N Nematodes

Cyclorana brevipes (Peters, 1871)
D *Dolichosaccus juvenilis*, (intestine)

Cyclorana cultripes Parker, 1940
D Allocreadiidae sp.
D *Dolichosaccus juvenilis*
D *Mesocoelium microon*

Cyclorana novaehollandiae Steindachner, 1867
N *Nematotaenia hylae*, (intestine)

***Cyclorana* sp.**
N Oxyurids, (rectum)

***Hyla* spp.**
for all *Hyla* species, see the *Litoria* equivalent, with the following exceptions:

i) *Hyla aurea* Lesson, 1829
for *Hyla aurea* from NSW (coastal area), see *Litoria aurea*
for *Hyla aurea* from SA, Tas, Vic, NSW (exclusive of coastal area), see *Litoria raniformis*
for *Hyla aurea* from WA, see *Litoria* spp.

ii) *Hyla ewingi alpina* Fry, 1915
see *Litoria verreauxii*

iii) *Hyla jervisiensis* Duméril & Bibron, 1841
for *Hyla jervisiensis* from all states, except SA, see *Litoria jervisiensis*
for *Hyla jervisiensis* from SA see *Litoria ewingii*

Litoria adelaidensis (Gray, 1841)
for *Litoria adelaidensis* from all states, except WA, see *Litoria* spp.
N *Parathelandros maini*, (rectum)
N *Maxvachonia flindersi*, (intestine)

Litoria aurea (Lesson, 1829)
for *Litoria aurea* from Vic, Tas, SA, NSW (exclusive of coastal area), see *Litoria raniformis*
for *Litoria aurea* from WA, see *Litoria* spp.
D *Diplodiscus megalochrus*, (rectum)
D *Diplodiscus* sp., (rectum)
D *Distoma* sp.
D *Gorgodera australiensis*, (bladder)
D *Gorgodera* sp., (bladder)
D *Haematoleochus australis*, (lungs)
D *Dolichosaccus anartius*, (intestine, rectum)
D *Dolichosaccus trypherus*, (duodenum)
D *Dolichosaccus* sp.
D *Mesocoelium mesembrinum*
D *Pleurogenoides solus*, (intestine)
D Digenea cysts, (nerves, muscles, subcutaneous)
D Digenea, (lung, intestine, rectum)
C ?*Ligula* sp., (muscles, peritoneal cavity, subdermal lymph sinuses)
C Diphyllobothriidae spargana, (thigh muscles)
C *Ophiotaenia* sp., (intestine)
C *Proteocephalus hylae*
C *Triplotaenia mirabilis*
C Cestodes, (intestine, muscle)
N *Rhabdias hylae*, (lung)
N *Rhabdias nigrovenosum*, (lung)
N *Rhabdias* sp., (lung)
N *Rhabdonema* sp.
N *Oswaldocruzia limnodynastes*, (intestine)
N *Falcaustra hylae*, (intestine)
N *Physaloptera confusa*, encysted larva, (mesentery)
N Nematodes, (lung, intestine, rectum, peritoneum, abdominal cavity, stomach)
A *Porrorchis hylae*, encysted larva, (mesenteries)

Litoria booroolongensis (Moore, 1961)
N Nematodes, (rectum, mesentery)

Litoria caerulea (White, 1790)
D *Diplodiscus megalochrus*
D *Diplodiscus* sp.
D *Dolichosaccus ischyrus*, (intestine)
D *Dolichosaccus symmetrus*, (rectum)
D *Dolichosaccus* sp.
D *Mesocoelium megaloon*, (intestine)
D *Mesocoelium mesembrinum*, (intestine, duodenum)
D *Mesocoelium microon*
D *Mesocoelium* sp.
D *Fibricola intermedius*, metacercaria, (muscles) paratenic host
D *Halipegus* sp.
D Digenea, (intestine)
C ?*Ligula* sp.
C Diphyllobothriidae spargana, (thigh muscle)
C *Nematotaenia* sp.
C Cestodes, (rectum)
N *Rhabdias hylae*, (lung)
N *Rhabdonema* sp., (lungs)
N *Parathelandros mastigurus*, (small intestine, rectum)
N Oxyurid, (intestine)
N *Maxvachonia flindersi*
N *Physaloptera confusa*, encysted larva, (stomach, peritoneum)
N *Agamonema* sp., encysted larva, (stomach wall)
N Nematode larva, cysts, (intestine)
N Nematodes, (stomach, intestine, rectum, lung, buccal cavity, abdominal cavity, muscle)
A *Porrorchis hylae*, encysted larva, (liver)
A *Acanthocephala* sp.

Litoria citropa (Duméril & Bibron, 1841)
M *Parapolystoma bulliense*
D *Mesocoelium oligoon*, (duodenum)

Litoria cyclorhyncha (Boulenger, 1882)

N *Parathelandros maini*, (rectum)
N *Maxvachonia flindersi*, (rectum)

Litoria dahlii (Boulenger, 1896)
D Digenea
N Nematodes

Litoria dentata (Keferstein, 1868)
N Nematodes, (intestine)

Litoria ewingii (Duméril & Bibron, 1841)
D *Diplodiscus microchrus*, (rectum)
D *Mesocoelium megaloon*, (intestine)
C *Nematotaenia hylae*, (duodenum)
C Cestodes, (small intestine)
N *Austraplectana kartanum*
N *Maxvachonia flindersi*
N *Hedruris hylae*
N Nematodes, (intestine, rectum, duodenum, mesentery)

Litoria fallax (Peters, 1880)
C *Nematotaenia hylae*, (intestine)

Litoria freycineti Tschudi, 1838
D *Dolichosaccus diamesus*, (stomach)
D *Pleurogenoides freycineti*, (duodenum)
C *Nematotaenia* sp.
C Cestodes, (duodenum)

Litoria gracilenta (Peters, 1869)
D *Mesocoelium microon*
N *Parathelandros mastigurus*, (rectum)

Litoria inermis (Peters, 1867)
C *Nematotaenia hylae*, (intestine)
N *Pseudorictularia disparilis*, (stomach)

Litoria infrafrenata (Günther, 1867)
N *Maxvachonia adamsoni*, (intestine)

Litoria latopalmata Günther, 1867
C Diphyllobothriidae spargana, (muscles), (experimental)
C *Nematotaenia hylae*, (intestine)
N *Rhabdias hylae*, (lung)

Litoria latopalmata Günther, 1867 tadpole
D *Fibricola intermedius*, metacercaria, (muscles)
C Diphyllobothriidae spargana, (experimental)

Litoria lesueurii (Duméril & Bibron, 1841)
M *Parapolystomum bulliense*, (bladder)
N *Rhabdias hylae*, (lung)
Nematodes, (rectum)

Litoria moorei (Copland, 1957)
D *Haematoleochus australis*, (lungs)
D *Dolicosaccus trypherus*, (intestine)
D Digenea, (abdominal cavity)
C *Proteocephalus hylae*, (intestine)
N *Rhabdias* sp.
N *Parathelandros maini*, (rectum)
N *Austraplectana kartanum*, (rectum)
N *Maxvachonia flindersi*, (rectum)
N Nematode larvae
A *Pseudoacanthocephalus perthensis*, (rectum, intestine)

Litoria nasuta (Gray, 1842)
N *Austraplectana kartanum*
N *Maxvachonia ewersi*

Litoria nigrofrenata (Günther, 1867)
N *Pseudorictularia disparilis*, (stomach)
N Nematodes

Litoria nyakalensis Liem, 1974
M *Parapolystoma* sp., (urinary bladder)

Litoria pallida Davies, Martin & Watson, 1983
C *Nematotaenia hylae*, (intestine)

Litoria pearsoniana Copland, 1961
M *Parapolystoma bulliense*, (bladder)
D *Fibricola intermedius*, metacercaria, (muscles) (natural & experimental)

Litoria peronii (Tschudi, 1838)
D Diplostomula
D Digenea cysts, (rectum)
D Digenea
C *Nematotaenia hylae*, (intestine)
N *Rhabdias hylae*, (lung)
N *Oswaldocruzia limnodynastes*
N *Physaloptera confusa*, encysted larva, (mesentery)
N Nematodes, (lungs, rectum)
A *Acanthocephala* sp.

Litoria phyllochroa (Günther, 1863)
M *Parapolystoma bulliense*, (bladder)
N Nematodes, (rectum)

Litoria raniformis (Keferstein, 1867)
D *Gorgodera* sp., (bladder)
D *Haematoleochus australis*
D *Dolichosaccus trypherus*, (intestine)
D *Dolichoperoides macalpini*, metacercaria, (intestine)
D Diplostomula
D Echinostome cysts, (stomach)
D Plagiorchid cysts
D Strigeid cysts, (body wall)
D *Tetracotyle* cysts
D Digenea, (intestine)
C *Ophiotaenia* sp., (intestine)
C proteocephalid plerocercoids
C Cestodes
C Cestode larva, (abdominal cavity)
N *Rhabdias hylae*, (lung)
N *Rhabdias* sp., (lung)
N *Rhabdonema* sp.
N *Oswaldocruzia limnodynastes*, (intestine)
N Oxyurids, (lung, rectum)
N *Physaloptera* sp.
N Nematodes, (mesentery, intestine, stomach, rectum)
A *Porrorchis hylae*, encysted larva, (mesentery)

Litoria rothii (De Vis, 1884)
D Digenea, (small intestine)

N Oxyurid
N Nematodes, (small intestine)

Litoria rubella (Gray, 1842)
C *Spirometra erinacei*
N *Parathelandros* spp., (rectum)
N Oxyurid

Litoria verreauxii (Duméril, 1853)
C Cestodes, (small intestine)
N Nematodes, (rectum)

***Litoria* sp.**
D *Dolichosaccus* spp.
D *Pleurogenes* spp.
C Cestodes

***Litoria* spp.**
identified as *Litoria adelaidensis* from NSW
N Nematodes

***Litoria* spp.**
identified as *Litoria aurea* from WA
C Diphyllobothriidae spargana, (thigh muscle)
N *Parathelandros* spp.

Family RANIDAE

Rana daemeli (Steindachner, 1868)
N *Rhabdias australiensis*, (lung)
N Cosmocercinae gen. sp. 1
N *Seuratascaris numidica*, (stomach, intestine)
N *Pseudorictularia disparilis*

Family BUFONIDAE

Bufo marinus (Linnaeus, 1758)
D *Diplodiscus* sp.
D Amphistome
D *Dolichosaccus symmetrus*, (intestine)
D *Dolichosaccus* sp.
D *Mesocoelium mesembrinum*, (small intestine)
D *Mesocoelium* sp., (intestine, abdominal cavity)
D Lecithodendriid sp., (intestine)
D *Zeylanurotrema spearei*, (urinary bladder)
D Digenea cysts
D Digenea, (intestine, stomach, rectum, abdominal cavity, lung, buccal cavity)
C Diphyllobothriidae spargana
C ?*Spirometra mansoni*, spargana, (muscles)
C Proteocephalid plerocercoids
C *Nematotaenia hylae*, (intestine)
C Cestodes, (intestine, stomach)
N *Parathelandros mastigurus*
N *Parathelandros* spp., (intestine)
N Oxyurid
N *Maxvachonia flindersi*, (rectum)
N Cosmocercoid
N Nematode cysts
N Nematodes, (intestine, rectum, abdominal cavity, stomach wall)
A *Pororchis hylae*, encysted larva

Unidentified Anura

Frog
D *Diplodiscus megalochrus*, (bladder)
D Echinostome cysts, (stomach)
D Digenea cysts
C Cestodes, (buccal cavity)
N *Austraplectana* sp.
N *Ophidascaris phyrrhus*
N Dorylaimid, (intestine)

Tadpole
D *Dolichoperoides macalpini*, metacercaria
D *Cercaria ameriannae*, diplostoma
D *Cercaria angelae*, cysts, metacercaria
D *Cercaria ellisi*, cysts
D *Cercaria lethargica*
D K.I. Stylet cercaria, (experimental)
D J.W. Stylet metacercaria
D Echinostome J cercaria, (experimental)
D Echinostome cysts, (experimental)
D Digenea cysts
D Digenea cysts, (experimental)
N *Ophidascaris pyrrhus*, (experimental)
N *Rallietascaris varani*

Acknowledgments

To each of the curators of the parasitic sections in the many museums in Australia and overseas that I contacted in the preparation of this work I express my deepest gratitude. I would also like to thank my fellow PhD students, Mr Steve Richards and Ms Sylvie Pichelin, for their much appreciated patient assistance with frog and monogenean taxonomy, respectively. Drs David Blair, Tom Cribb, Ian Beveridge, and Margaret Davies, and Mrs Pat Thomas who offered advice and support throughout the preparation of this manuscript, also receive my warmest thanks.

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MATERIAL CULTURE TRADITIONS OF THE WIK PEOPLE, CAPE YORK PENINSULA

P. SUTTON

SUTTON, P. 1994. Material culture traditions of the Wik people, Cape York Peninsula. *Rec. S. Aust. Mus.* 27(1): 31–52.

This paper draws upon the author's fieldwork among the Wik people since the 1970s to present a summary of the material culture traditions of central-western Cape York Peninsula. Historical sources, particularly the ethnographies of the anthropologists Ursula McConnel and Donald Thomson, provide additional detail.

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Since the 1970s the Australian Aboriginal people whose traditions of material culture are presented here have been known to anthropologists as 'the Wik speaking peoples' or just simply 'the Wik', but there is no cover term for them in their own languages, nor is there any evidence of such a term in the past. They share most of their autogenous material culture with their near neighbours, but in several ways they remain a recognisable cultural entity. Their focal area lies between the Archer and Edward Rivers, western Cape York Peninsula, Queensland, and inland to Coen. Most Wik people still live in this triangle (Fig. 1).

The Wik include most of the population of Aurukun and its outstations (hence 'Aurukun people') and that part of Pormpurraaw's population known as 'Mungkan side'. They also include west-side people affiliated with languages such as Mungkanho and Wik-Iiyeyn who live at Coen and Meripah in central Cape York Peninsula. The Wik-Way, with countries between Aurukun and the Mission River to the north, are now also effectively Wik people through culture change in the present century. Misleading cover-terms for the Wik include 'the Wik-Mungkan' and 'the Aurukuns', the latter sometimes occurring in news media.

The people discussed in this paper are those who are members of clans with traditional estates along the coast south from Love River to between Christmas Creek and Breakfast Creek, and inland from the middle Archer River south via Rokeby and Meripah to the upper Holroyd. There are perhaps fifty such estates clustered intensively along the narrow coastal flood-plain and occupying very much larger expanses in the forest and savannah woodland country of the uplands. Detailed maps and site records for many of these estates are to be found in Sutton, Martin, von Sturmer, Cribb & Chase (1990). For detailed studies of the traditional land relationship systems in the area see especially Sutton (1978) and von Sturmer (1978).

The most dramatic environmental feature of the region is the contrast between the food- and resource-rich coastal strip, at times only a few kilometres wide and subject to massive wet season flooding, and the vast, gently undulating hinterland with its relatively simple flora and restricted faunal range broken only here and there by riverine gallery forest and its complex of resources.

Proceeding inland from the coast, the major environmental zones are:

1. the beach dunes, grading from fine sand to coarse shellgrit, sparsely shaded and offering limited saltwater resources in the intertidal zone;
2. the dune woodland along the eastern edge of zone 1; extremely rich and complex both florally and faunally;
3. grassy flood plains and huge saltpan/mangrove areas, rich in birdlife and, in its freshwater lakes or in its tidal estuaries and waterholes, rich in marine life; inundated during and after the wet season;
4. another zone of dune woodland on Pleistocene sandridges, running approximately in parallel with the present coast; rich and complex in patches;
5. relatively open bloodwood and eucalypt forest, punctuated by intermittent, broad watercourses bearing melaleucas, and containing a large number of permanent swamps;
6. riverine gallery forest fringing permanent streams characterised by white sandy beds in many sections (chiefly the Archer River system; also Kendall River);
7. grassy savannah woodland with occasional outcrops of stone and gravel; this is generally the westernmost limit of European pastoral activity, although the Aboriginal communities have turned off cattle from the coastal area at various times since the 1930s.

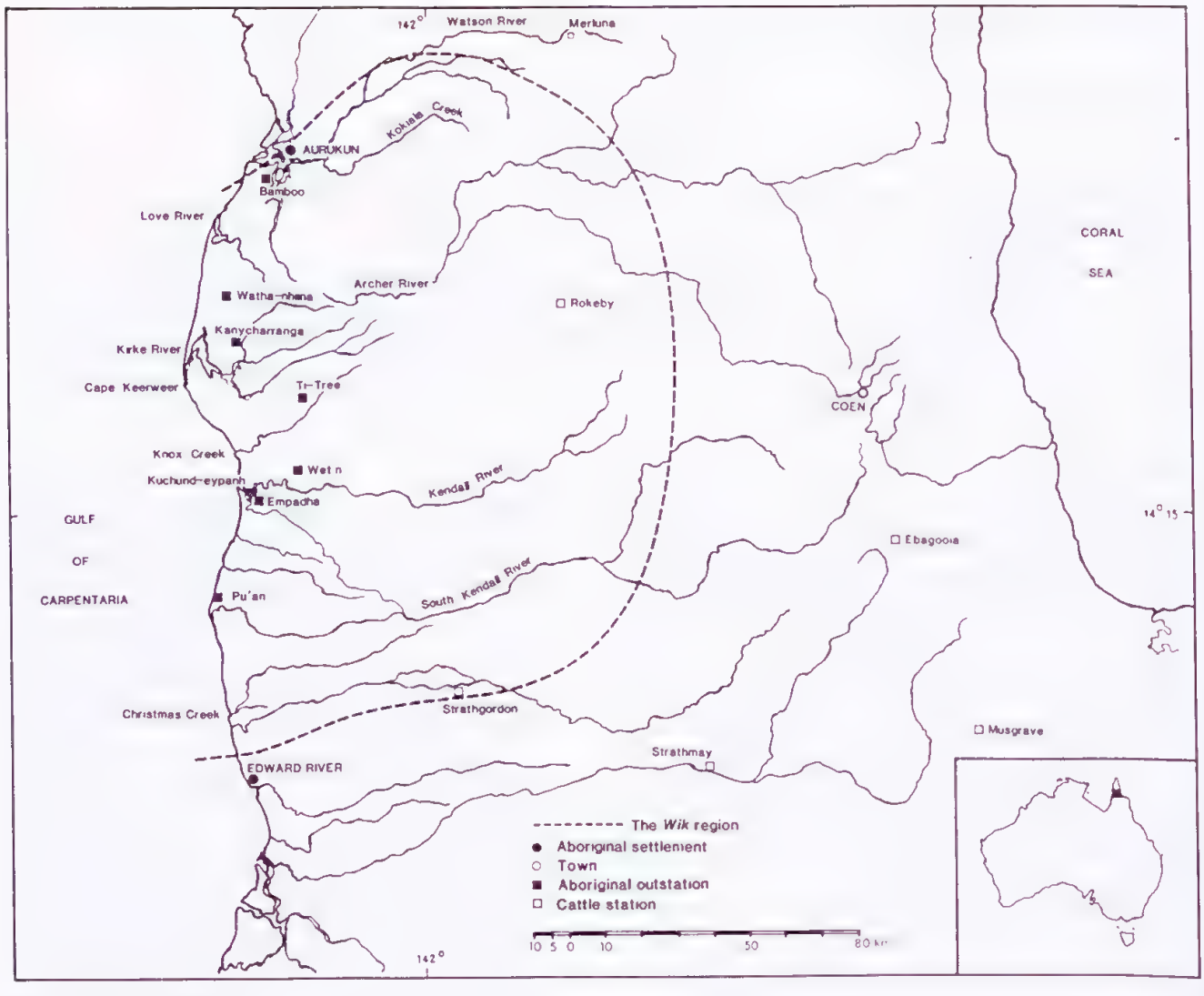

FIGURE 1. The Wik region.

Socio-cultural groups

The most important social distinction within the Aboriginal population of the region is that between 'top side' and 'bottom side', a reflection of the origins of most of the Wik in countries located either inland ('top side') or on the coastal strip ('bottom side'). Traditions of material culture also reflect this distinction, which is one that has been under-recognised by some previous anthropological writers (e.g. Thomson 1939a, McConnel 1953).

Among the coastal peoples it is possible to recognise major subgroups consisting of those whose clan estates cluster around certain rivers or creeks. Thus there are, going from north to south, the Love River people, those of the Kirke River ('Cape Keerweer people'), Knox River people, Kendall River people and so on. These are not linguistic groups, but regional groups which have tended to closely intermarry, share religious cults, and unite at times in conflict with others. In the 1980s and 1990s the clarity and prominence of these distinctions were waning while the top/bottom distinction was being strongly maintained. At the same time, the old regional ceremonial divisions (Apalach, Puch, Wanam etc.) were still known but their ceremonies were being performed less often, less fully, and in fewer contexts.

There are no simple political linguistic groups ('dialectal tribes') in this region (see Sutton 1978, Rigsby & Sutton 1980–82). The people do own, by right of clan birth and country, a recognised variety of languages. In the case of the Wik, all of these languages belong to a single genetic family known as the Wik group. About fifteen named languages constitute this group. This includes languages named with the prefix 'Wik-' ['Language-'] (for example: Wik-Mungkan, Wik-Iiyanh, Wik-Ngathan, Wik-Ngatharr, Wik-Ep, Wik-Me'anh, Wik-Keyangan), those named with the prefix 'Kugu-' ['Language-'] (for example: Kugu-Uwanh, Kugu-Muminh, Kugu-Ugbanh, Kugu-Mu'inh), and some with no prefix (e.g. Mungkanho).

Adults and most children have variable knowledge of many of these languages, including full competence in up to four or five in some cases,

although several of these languages were in advanced stages of decline and some were virtually extinct by the late 1970s (Sutton 1978). By the 1980s and 1990s Wik-Mungkan and English were the dominant languages of the Aurukun area, and Wik-Mungkan was the first language of most children. Several hundred people, however, had partial or excellent knowledge of Wik-Ngathan or Wik-Ngatharr, and most languages had at least some surviving speakers.

Prehistory

The archaeology of the region was virtually unknown as late as 1985. Roger Cribb has carried out some preliminary survey work (Cribb 1986, Cribb *et al* 1988), paying particular attention to the spectacular shell mounds mapped at Love River by Cribb, Sutton, Martin and Chase in 1985. The Aboriginal custodians of these mound sites, as well as their neighbours, consider the mounds to be of non-human origin and to be 'story places'.

Perhaps the most interesting fact about the prehistory of the area is that the zone of greatest recent population, the coastal plains and dune systems, is geologically very young. The coast has been prograding, probably under constant human occupation, for about 6 000 years (Rhodes 1980). The human role in its formation as a mosaic of vegetational complexes has yet to be investigated in any detail.

Population

In 1988 some 900 Wik people lived at Aurukun and its handful of outstations. A few hundred more lived at Edward River, Coen, Kowanyama, Mornington Island and other centres such as Cairns. Their numbers had been increasing for some decades, after an initial sharp drop caused by European, Asian and Islander (Torres Strait and Pacific) incursions into the wider region in the late nineteenth and early twentieth centuries.

In 1930 Ursula McConnel estimated the coastal Wik people to number two or three hundred (1930: 99). She thought that 'the Wik-Mungkan' had originally numbered 1 500–2 000 people before the inroads of exotic diseases (1930: 181). In 1965 the Aurukun Aboriginal population, which contained most of the Wik people then alive, was 603 (Long 1970). Only sixteen years earlier the majority of the Wik population had been classed as 'nomads', living in the reserve but in touch with the mission since at least 1938. By 1957, most of the Kendall and Holroyd Rivers people had settled at Edward River or Aurukun, leaving only a small group (Tiger's mob) still living in the bush by the 1970s (Long 1970: 144–5; J. von Sturmer pers comm).

In pre-mission times population density along the coastal plains and dune systems was an estimated one person to 2.3 square miles (5.91 square kilometres; Sutton 1978: 90). This figure is based on a reconstruction using clan maps and an estimate of an average 20 persons per clan. A little further to the south, in the Mitchell River region, Sharp came to a comparable figure of one person to 2.4 square miles (6.19 square kilometres) in a census of bush-dwelling coastal people in 1932 (Sharp 1940: 487). These figures are at the high-density end of the scale for Australian Aborigines (see Maddock 1972: 22–3) and are vastly higher than what one might expect for the hinterland groups, were parallel figures available.

Material culture

Raw materials

The coastal Wik region is practically devoid of stone and certainly devoid of hard stone suitable for tool-making. There are stony ridges, however, in the hinterland far to the east. In many months of combing the coastal and peri-coastal country while mapping old habitation and other sites with Wik people this author has only found two stone artefacts, both axe heads. Such stone must have been traded in from a long distance. Apart from local ochres, and the mud and shale used in cooking, most raw materials come from plants (wood, bark, seedpods, grass stems, leaves, sap) and animals (bone, teeth, feathers, shell, spines, wax, hair).

Settlement and shelter

In recent decades most Wik people have made use of tropical western-style housing when living in a settlement village such as that of Aurukun (Fig. 2). On the fringes of settlements and at outstations and temporary bush camps they make use of tin sheds, corrugated iron lean-tos, and tents. Leafy branches are used for daytime shades and when not using a house people would sleep in the open on the ground or, in earlier days, on elevated platforms during the dry months of the year. Houses and sheds were used to store possessions and to keep food from the unwanted reach of dogs and visitors, and were often too hot to use in the daytime. People tended to live under and near, rather than in, a modern house, up to the 1980s.

Thomson (1939a: 218) illustrated and described the traditional camps and house types of the region. Wet season huts on the coast (Fig. 3) were made of

FIGURE 2. Modern housing with group preparing for ceremonial house-opening, Aurukun 1987. Photo: Dale Chesson.

melaleuca bark (especially *M. leucadendron* (L.)L. and *M. viridiflora*). In the inland areas the huts were of stringybark (*Eucalyptus tetradonta* Thomson 1939a: 218) or messmate (*Garcenia warrenii* F. Muell. Sutton & Smyth 1980 item 60). These two types of hut were given distinct names in languages such as Wik-Ngathan and Wik-Mungkan and were among the many typifiers of differences between the salt-water people and their inland neighbours, the fresh-water people. Melaleuca bark is the preferred material.

On the coast, wet season camps were generally located under the huge spreading branches of trees such as the fig (*Ficus microcarpa* L.f.) or the milkwood (*Alstonia actinophylla* (A. Cunn.) K. Schum.), where the circular depressions of the floors of earlier huts could still be seen in the dune sands in the 1980s. These trees were a protection against torrential rain and stormy winds. The huts were filled with smoke from a small internal fire and their one or two small entrances closed off once people were inside, to keep mosquitoes at bay. Dry

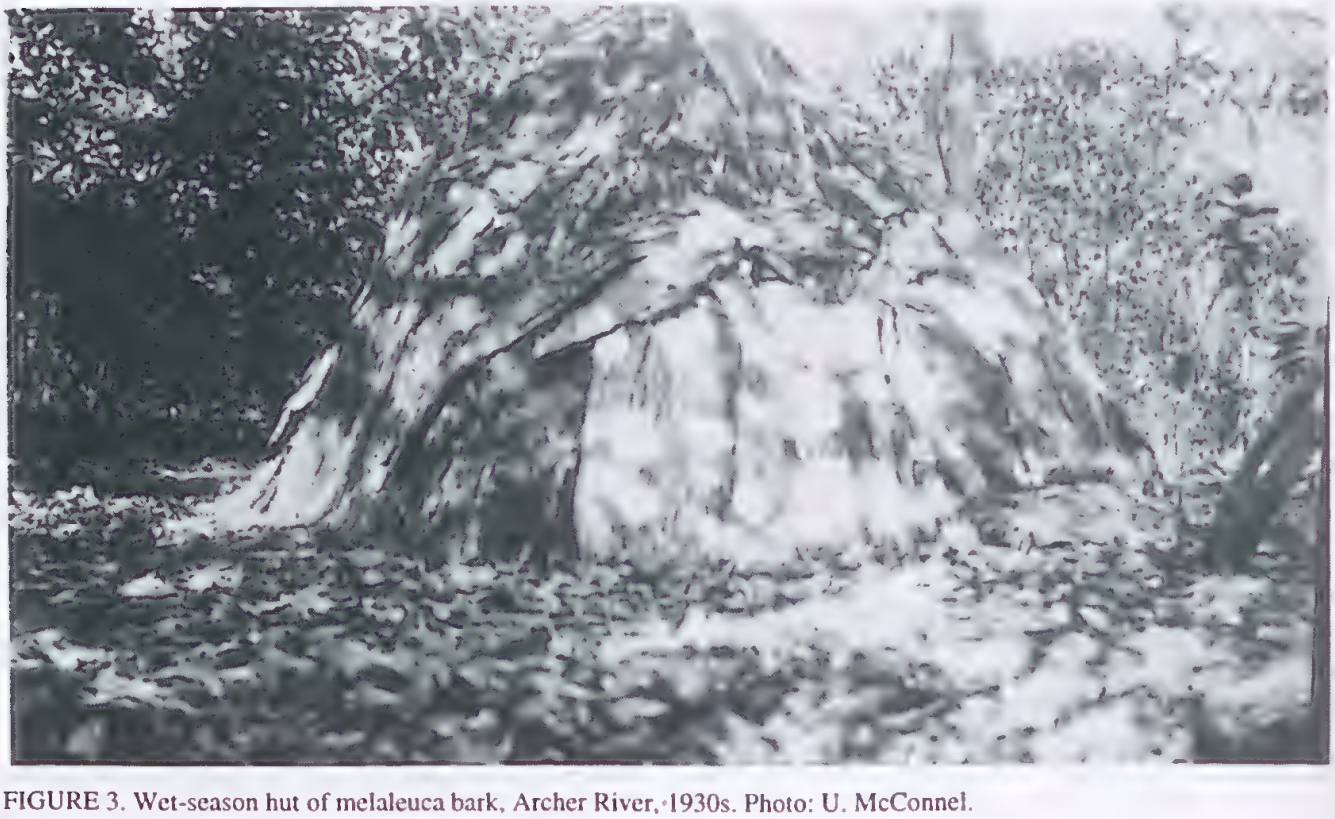

FIGURE 3. Wet-season hut of melaleuca bark, Archer River, 1930s. Photo: U. McConnel.

season day camps also favoured large shade trees, and therefore dune woodland or upland forest environments, and were often at some distance from night camps. A quickly erected day shade was made by cutting young saplings and leaning them like a brush fence against a pole or spear resting on forks of two adjacent trees. A siesta under shade in the heat of the day was common practice, especially for older people who had spent the small hours of the morning awake, tending fires and keeping watch.

Night bush camps in dry weather were generally in entirely open environments such as level parts of sand dunes, salt-pans, coastal swales or grass plain. The preferred dry season camp was soft sand, free of grass or trees, offering long-distance all-round visibility as a defence against snakes and human intruders, and catching a breeze which would keep the mosquitoes down (see Thomson 1939a Plate 23).

Fire

Before matches were introduced, and in remote bush camps of the 1970s when matches had run out, a fire-drill was used (Fig. 4). Two lengths of young wood from the firestick tree (*Premna* sp.) of 100 to 150 centimetres were stripped and dried and carried in a distinctive bamboo socket bound by yellow orchid stem and decorated with jequirity ('crab's eyes' or 'gidigidi') beads (*Abrus precatorius* L.). One of the sticks was held on the ground by the foot while the other was twirled by a person who stood up during the process. While *Premna* sp. was the preferred firestick wood, young stalks of the spear-handle tree *Hibiscus tiliaceus* L. were also used.

FIGURE 4. Fire-making, Cape York Peninsula 1930s. Photo: U. McConnel.

During field work in 1979, Dermot Smyth and this author recorded 37 botanically distinct types of firewood in the coastal and near inland zones between Archer River and Holroyd River. Our informants included older people who had lived their early lives in the bush, away from the mission. Of the various firewoods, 15 were considered good to excellent, 19 were considered acceptable, one was of use only as a last resort, one was regarded as tinder for lighting a fire, and another was only mentioned as kindling wood (any dry grass or fine dry twigs could be used as kindling). The preferred firewoods are marked as such in Sutton & Smyth 1980.

Fire was a constant factor in camp life, in travel, and in the hunting economy. Decisions on where to place hearths, how many hearths were required for a camp, how individuals oriented their heads when sleeping next to fires, and from whose fire a brand could be taken for the starting of another fire, all had important implications for the definition and negotiation of relationships between individuals and groups. In all the Wik languages, 'wife' is 'woman fire(-from)' and 'husband' is 'man fire(-from)'. The significance of fire and its sharing in traditional Western Cape York Peninsula culture is described in some detail by Thomson (1932).

In the course of a day, a particular individual might sit at several different fires within the same camp. In the daytime, a young bachelor might use a fire lit for a brief amount of cooking or boiling a billy for tea on a hot exposed patch of sand near a day-shade but in the full sun. Back at the base camp, in the evening, he might sit and eat with his parents or his sister and brother-in-law. For sleep, though, he might go to a fire which formed the nucleus of a sleeping-place for several other unattached adult men.

When people were dependent entirely on hunting and gathering for food, sections of grass-plain were fired systematically in the coastal region so that small mammals and reptiles could be harvested. As the vegetation dried off after the wet season, people set fire to the bush wherever they went, in order to clear the country for better hunting, for protection from snakes, for ease of travel and for improved visibility in the constant watch for enemies. These fires also marked the positions of bands of people, providing important information to their neighbours about their direction of travel. In the 1990s it was

FIGURE 5. Women digging rush corms, Archer River, 1930s. Photo: U. McConnel.

FIGURE 6. Women gathering water-lily seeds and pods, Archer River, 1930s. Photo: U. McConnel.

still normal practice to fire country during bush trips by vehicle and to light small fires as a signal of one's approach to an outstation camp. Rights in the firing of one's clan estate were not open to all, however, and disputes could arise over wrongful firings.

Subsistence activities

The basic facts of the seasonal regime and traditional subsistence economy in the region are well known, and have been the subject of publications by Thomson (1939a), McConnel (1953, 1957), and Chase and Sutton (1981). (See also von Sturmer 1978.) The following summary emphasises material culture and also contains new information.

The major vegetable foods in the pre-settlement economy were tubers, waterlilies, and an enormous variety of fruits. Nuts, the soft inner bark of two fig species, and the core of a *Livistona* palm were also eaten. Digging sticks were used, mainly by women, to obtain arrowroot (*Tacca leontopetaloides* (L.) Kuntze), round yams (*Dioscorea sativa* var. *rotunda*) and long yams (*Dioscorea transversa* R. Br.), which constituted staples (Fig. 5). Other tubers such as the *Cayratia* spp. known as *kaayketh* and *walken* respectively (in Wik-Ngathan) were cooked in the ashes (along the coast), or in an earth oven (inland), but were not major foods. Of the tubers, only long yams were still commonly dug in the 1980s, as their preparation (brushing the sand off) and cooking (in ashes) required little effort.

Another staple was the lotus lily (*Nymphaea lotus* L. var. *australis* F. M. Bailey). Its young stems were eaten raw and its roots and seeds roasted. Even the flowers yielded sweet morsels. It was extremely abundant in the wetlands of the coastal region (Fig. 6).

Like the arrowroot and round yam, mangrove fruits provided abundant foods but also required considerable processing. In particular, the grey mangrove (*Avicennia marina* (Forssk.Vierh.)) and the small black mangrove (*Bruguiera gymnorhiza* (L. Lam.)) provided bulk carbohydrate, although by the 1970s these foods were no longer in any regular use.

The sweeter fruits, mainly growing on jungle trees in the dune woodland zones, were usually eaten raw, although several species were cooked because of their tartness when raw. Sutton and Smyth list seventeen fruits of these kinds (1980).

FIGURE 7. Women using baler shell to obtain water from a well to wash, Archer River, 1930s. Photo: U. McConnel.

FIGURE 8. Spearing fish with a two-pronged spear and spearthrower, Archer River, 1930s. Photo: U. McConnel.

The major ones were the yellowfruit or nonda apple (*Parinari nonda* F. Muell.. ex. Benth.) which was collected in large quantities and stored; the various *Eugenia* and *Ficus* species (several of each); the black cherry (*Mallotuspolyadenus* F. Muell.); the redfruit (*Mimusops elengi* L.); the wild mango (*Planchonia careya* (F. Muell.) Knuth.); the wongai or black cherry (*Pouteria sericea* (Aiton) Baehni); and some of the *Terminalia* spp..

One of the figs, the pandanus and the 'monkey nut' tree (*Sterculia quadrifida* R. Br.) provided nuts which required different levels of preparation for eating.

Wild honey from the various *Trigona* spp. was a much sought-after food, occurring in relative abundance in the woodland region east of the flood plain and on some sandridges in the coastal zone. Stone axes (see McConnel 1953: Plate 12: b & p.24) were important for obtaining bee nests from hollow trees, but axe heads were traded in from elsewhere (McConnel 1953: 11). During the 1970s this author found a ground axehead at Uthuk Awuny (Big Lake) but it appeared to have had its blade abraded through use as a pounder. Hafted stone pounders are reported from the area nearby to the south (Thomson 1936: Plate 8).

Mice, bandicoots and reptiles such as lizards and edible snakes were dug from their nests with digging sticks of the same kind used for digging tubers. For digging in soft sand or wet mud, baler shells were excellent implements and were still in frequent use in the 1980s.

A baler shell on the ground was a common sign of the presence of a well. Although potable surface water was abundant in the wet season, it was not so in the dry season, except inland beyond the extensive tidal limits where permanent lagoons or the perennial streams of the Archer and Kendall Rivers provided fresh water. Coastal people preferred to dig a well, even next to a large pool of water (Fig. 7). The most preferred water was that occurring in the acquifers of ridges based on shellgrit. This water is nearest the surface, clears quickest after the water level has been dug out, and tastes sweetest. Next is sandridge water, followed by water which has to be dug in muddy soil. Considerable etiquette and religious formality (and, occasionally, vehemence) accompanies the digging

FIGURE 9. Morrison Wolmby, Noel Peemuggina and Alan Wolmby standing with spears, Aayk (Cape Keerweeer area) 1976. Photo: Peter Sutton.

of wells. Ancestors are informed of who is present, requested to do no harm to the diggers, asked to make the water come close to the surface, and so on.

Along the coast, fish, sharks and rays were a major food source. The actual Gulf beaches were not as attractive as the peri-coastal waterways and much if not most fishing seems to have been done in tidal reaches, estuaries and lakes. A good deal of this fishing in earlier times involved the use of drives, of weirs or fences across waterbodies, of vegetable stupefacients (for example, the bark of the bauhinia *Cathormion umbellatum* (Vahl) Kosterm., and *Ormosia ormondii* (F. Muell.) Merrill), of a variety of nets (ovate, reinforced with a cane withy), or of three- or four-pronged spears. Rolled melaleuca bark provided a torchlight for luring, confusing and illuminating fish during night hunting. Women occasionally speared fish but spears in general were men's equipment. Multi-pronged spears, barbed with bone or, more recently, nails, have generally given way to wire-pronged spears for obtaining marine species, and shotguns and .22 rifles had, by the 1970s, generally replaced spears for birds, pigs and wallabies. The old wooden-pronged spears were used for spearing birds and mammals as well as marine species (Fig. 8), and some of the single-pronged spears were used for fish, so it is impossible to claim that hunting spears were highly specialised. A very common spear type was the hardwood-headed spear with a double-pointed single barb of bone (later steel). This was used mainly for bigger land game but also for fishing (see e.g. Thomson 1939a: 210, McConnel 1953: 26). It is possible, though, to differentiate between spears for hunting and those specifically made for fighting (see below), even though, in an affray, any handy projectile might be used. In the 1970s in the Cape Keerweer region this author saw a stingray 'speared' with a long-handled shovel, fish 'caught' in a creek with shotgun blasts, and a *Varanus* goanna felled by thrown sticks gathered from the ground on the spur of the moment. Similar improvisations were probably resorted to in earlier times as well. Catching certain marine creatures by hand was a prized skill, although some sluggish fish in drying pools of water were an easy catch. Water birds are said to have been caught by swimmers

FIGURE 10. Man repairing spear point, Archer River, 1930s. Photo: U. McConnel.

pulling them underwater. More often the men, disguised with mud, and with only their nostrils and forehead above water, would swim slowly among the birds before startling them into flight. A number could then be brought down with a single spear or a couple of sticks.

Large quantities of spears, most of them well over two metres in length, were a distinctive mark of a western Cape York traditional camp (see Thomson 1939a Plate 23: lower, and Fig. 9 here). Spear-making (and constant repairing) was a major occupation for middle-aged and older men (Fig. 10), and in the 1980s continued as a source of income. The problem of marketing spears through the craft outlets was diminished by the introduction of detachable sections. Traditional spears were sometimes made in three sections, and commonly in two, so the adaptation was not a major one. The sectioning was designed to yield an optimal combination of lightness, strength and flexibility. It must be remembered however that, in use, spears were essentially fragile and frequently broken or damaged.

Whenever possible, spears were propelled by the use of the distinctive Cape YorkPeninsula spearthrower with its long, slender body, baler shell balance, attached peg, and occasional decorations of *Abrus* seeds and yellow orchid stem binding (Figs. 8,11). A lightweight version capable of floating was sometimes used when on the water, and a 'false

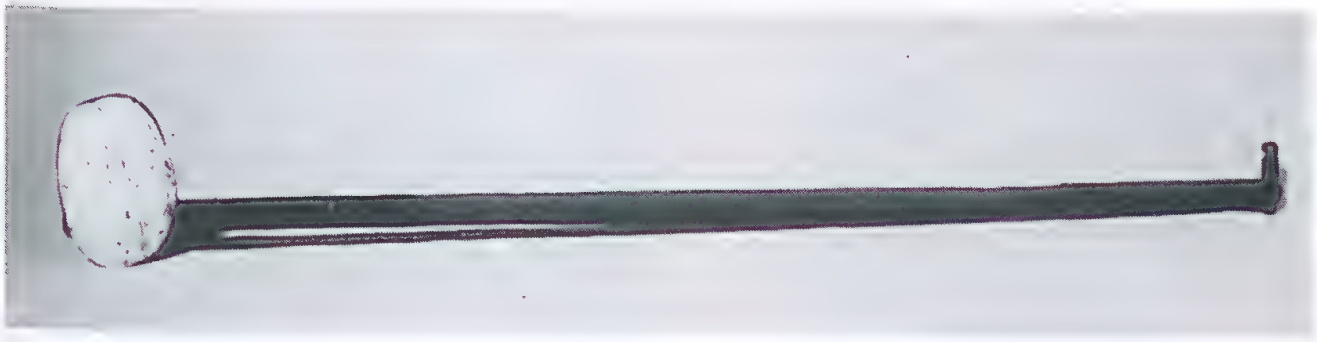

FIGURE 11. Spear-thrower made in 1977 by Clive Yunkaporta, Peret Outstation via Aurukun.

woomera' was used in conflict (see below).

The inland economy was dependent on fewer vegetable staples and a narrower range of other vegetable foods, rather widely dispersed. It was also focused on freshwater lagoon and river fish and shell species and on reptiles. Apart from kangaroos and emus, which could not be relied upon as an obtainable protein source from day to day, possums and bandicoots would have been among the larger animals in the diet. By contrast, the coastal economy offered not only more variety and greater concentrations of foods, but also more abundant large-bodied animals such as the wallabies of the dune systems, the sharks and rays of the estuaries, and, since the 1920s, feral pigs in large numbers.

Cultivation and domestication

In pre-mission times people optionally left *in situ* the stem and vine of a tuber they were digging out so another would grow on the same vine. In the 1970s this was still occasionally the practice. By the 1970s, cultivation of introduced food-bearing plants such as watermelon, bananas, pawpaw (papaya), cassava and coconuts was also occurring in very small plots near outstation camps or planned outstation sites, as well as here and there in the Aurukun village itself. The ravages of vermin, dogs and children, problems with water supplies, and the intermittent absence of the garden's personal cultivator, frequently led to these gardens falling into disuse. Much of their function was to act as symbolic claims on place, or as signs of diplomatic intent towards Europeans, who have so often expressed a desire to see Aborigines interested in agriculture. The slightness of their production was not critically important.

As elsewhere in Australia, camp dingoes were quickly replaced with European dogs and large numbers might become attached to Aboriginal households in the area. Dogs continued to be regarded as kin and to bear an array of clan-totemic names at least well into the 1980s, although most also acquired English names. They, like their predecessors, were of continuing use as watchdogs and of occasional use as hunting aids, and they remained kin.

By the 1970s piglets had become gifts and some survived to become members of camps, at least in remote places such as Ti Tree. Their tendency to bully humans for food can become rather alarming by the time they reach full adult size and they sometimes meet untimely ends at that stage.

European cats are occasional pets but their feral cousins were not prime hunting targets as they are in much of desert Australia. Those kittens which survive the attentions of small children might develop a loose relationship to certain households but do not achieve the valued status of dogs. They lack precedent.

Horses and cattle formed a focus of work and life for many Wik people for much of the mid twentieth century, although care and maintenance of herds, fences, plant and equipment were intermittent and depended on a small number of dedicated Aboriginal stockmen and occasional European managers. While the strong arm of the mission was in charge, the Aurukun cattle industry turned off beasts, barging them out off the coast or walking them overland as far as the railhead at Mungana some 400 kilometres to the southeast. In the 1980s, after the cattle operations had been in disarray and decay for a decade or more, Aurukun Community Incorporated organised the eradication of cattle from the Aurukun Shire as part of the Australia-wide brucellosis and tuberculosis eradication campaign.

Food preparation and consumption

While heavy game might be transported tied to a long pole carried by two people, under bush conditions most foods were carried in woven bags or in containers made from hardwood bark (Fig. 12). Food was also wrapped in paperbark (from *Melaleuca* spp.) and tied with vines or grass, both for transportation and warming near a fire. Paperbark is in fact the commonest and most versatile natural material in the western Cape York traditional subsistence kit (Figs. 13,14). The uses of paperbark extend well beyond subsistence, but

FIGURE 12. Women with heavy loads, Archer River, 1930s. Photo: U. McConnel.

because of its special role in cooking and eating we will deal with all of its uses here.

Paperbark is used as a food preparation surface on which meat can be sliced or a damper kneaded (Fig. 15), a coverlet to shield food from flies or dogs, a source of kindling when outer barks and grasses are wet, a heat-sealing medium for meats in earth ovens, a mitt with which to pick up steaming hot foods or billycan handles, a platter from which to eat, a towel with which things are wiped, a lightly abrasive cleaner (when crumbled) for greasy or blood-covered hands, a clean, dry surface to sit or sleep on, a blanket to sleep under, a shroud in which to mummify and transport corpses, a roofing material for shelters, a torch for night travel or fishing, a pouch for containing stingray barbs or small medicinal or magical substances, a cigarette paper, a binder for awl handles, a napkin for babies, a menstrual pad, and a sheet of toilet paper. Its abundance in coastal swamp areas is one of the

FIGURE 13. Stripping paperbark from a melaleuca tree, Archer River, 1930s. Photo: U. McConnel.

factors which makes the coastal region such a convenient place to live, compared with the inland. The preferred species provide sheets of soft, durable material which are easily prised from the tree with a sharp stick, which impart little or no odour or taste to food and which leave no sharp or stringy fragments behind when fragmenting.

Most cooking was carried out by simple broiling on an open fire, or by the earth oven technique. Shark or ray liver, however, might be fried in a baler shell, or lightly cooked before being wrapped in the washed white flesh of the shark or ray and then tied up in paperbark to be slowly warmed through at the hearthside. This distinctive loaf of high vitamin and protein content gives rise to the term by which most Wik people refer to the elasmobranch (sharks and rays) category: 'tying meats' (for example, minh katheng in Wik-Ngathan). The sign for the same category is the wringing of hands, a reference to the squeezing of white fluid from the flesh after cooking and before eating.

The earth oven technique was used for large game, but also for large quantities of small game such as marsupial mice and fruit bats or vegetable foods such as tubers. The following description of that method is probably only strictly true for the coastal region, where there is no stone. (Note also that other cooking practices varied within the region: inlanders cooked the tuber known as *angk* (Wik-Mungkan) or *walken* (Wik-Ngathan), probably a *Cayratia* sp., in the earth oven, but coastal people roasted it in the coals; some coastal clans half-cooked stingray livers, while others placed them raw inside the white flesh. These differences were

FIGURE 14. Carrying sheets of paperbark, Archer River, 1930s. Photo: U. McConnel.

FIGURE 15. Paddy Yantúmba removing eggs from a file snake, Big Lake 1976. Photo: Peter Sutton.

consciously maintained as an aspect of local group identity.)

To make an earth oven, a pit was dug and a vigorous blaze lit in it (Fig. 16). On this fire, or one nearby, the fur, skin or scales of the beast were singed away and the burnt fragments lightly scraped off. Lumps of termite mound, if available, were thrown into the pit to get hot. (The earth oven technique is known as '(burying) in termite mound'.) Where there was no termite mound - whose heat-holding properties are exceptional - lumps of shellgrit were used. At the bottom of this hierarchy of oven bricks was swamp mud, a last resort when the other two substances could not be had. Termite mounds are thus a factor in defining optimal campsites in the region.

When the oven bricks were hot, they were covered in green leaves on which the meat was placed skin-side up. Large sheets of paperbark (or, in the 1980s, corrugated iron if available) were then placed on the meat and the whole oven was sealed with sand. The relative ease with which the pit could be dug and the oven properly sealed depended on the presence of sand, and the whole process usually required access to suitable paperbark trees, which were thus further factors in defining a good campsite location. Earth ovens were usually near, not right on, overnight and base camps. They accumulated quantities of offal, skin, feathers and bones which made the immediate area unpleasant for camping. The termite mound lumps were re-used until fragmented, on subsequent visits to the site.

Limited food storage was practised. Nonda plums

FIGURE 16. Earth oven cooking, Watha-nhiin Outstation, 1976. Photo: Peter Sutton.

(*Parinari nonda* F. Muell. ex. Benth.) were dried on the rooves of shelters, or collected dry from the ground (the dry form even has a different name), and were kept for some weeks after their season of superabundance. Long yams (*Dioscorea transversa* R. Br.) were stored in the sand for weeks and even months (Sutton and Smyth 1980). Long-necked turtles might survive a day or two trussed up, and in the Big Lake area barramundi is said to have been cooked, wrapped in paperbark, and buried in the cool earth for eating days later. Most food, however, was eaten within twenty four hours.

Food preparation was elaborate in the case of vegetable foods with toxic or unpleasant properties which required scraping, pulverising, leaching and sieving (for example, the round yam *Dioscorea sativa*, the arrowroot *Tacca leotopetaloides* (L.) Kuntze, or the mangrove fruit *Avicennia marina* (Forssk.) Vierh.). These were not preferred foods and by the 1970s most had become just a hardship memory. Nonda plums were pounded and mixed with water to make a kind of fruit soup (Thomson 1939a), much favoured by children and by the toothless. A wooden mallet and pounding board were used in these processes, and mashed food was collected in large messmate bark containers (Fig. 12). This same bark (from *Garcinia warrenii* F. Muell.) was also used for canoes, sleeping platforms, and inland shelters. It is a characteristic resource of the hinterland behind the narrow coastal floodplain.

Foods were mixed in earth ovens in order to create changes of flavour, and some non-foods were used as condiments in the same context. For example, the leaves of two eucalypts known in English as 'bloodwoods' (but named separately in Wik languages) were placed in earth ovens with the meat of game such as wallaby or wild pig to improve their flavour. This attention to culinary detail marks the culture of this kind of region as very different from, for example, the cooking styles of people of the Western Desert.

Travel and transport

By further contrast with inland peoples, and especially those of desert Australia, in pre-settlement times Wik people were comparatively sedentary, making less frequent shifts of camp and travelling much shorter distances between camps. Base camp shifts were usually about five or six kilometres only. People were therefore able to carry more possessions, and lived in an environment rich in a wide variety of raw materials from which artefacts might be made. It is not surprising, then, that the inventory of their material culture is relatively large.

FIGURE 17. Noel Peemuggina and Johnny Ampeybegan drinking from baler shells at the beach near Big Lake, 1976. Photo: Peter Sutton.

FIGURE 18. Woman weaving basket, Archer River, 1930s. Photo: U. McConnel.

Message sticks, which were small tablets of wood carved with non-figurative symbols representing days of travel, places, people or commodities, were carried by messengers when arranging meetings or other dealings, both ceremonial and secular (McConnel 1953, Sutton 1978: 93–4).

The variety of containers used to transport or hold things in this region was, perhaps, exceptional. In addition to the woven bags and baskets discussed below, and the bark containers discussed above, there were the ubiquitous baler shell (used for drinking (Fig. 17), digging, baling and cooking as well), the conch shell and bamboo tube (for transporting water), the palmleaf cup, and the carved wooden vessel (see Thomson 1939a: Pl.XXI, 1939b: 85).

In the 1980s women of the Wik peoples were still making a variety of differently shaped woven bags and baskets employing many different fibres and weaves, and a number of natural dyes (see Adams 1986, McConnel 1953, Thomson 1939a). These were used not only for carrying things, but also for sieving and leaching bitter foods, for hanging valuables high above the reach of children and dogs, for imparting a militant spirit to small boys (by smacking woven bags against their calves), and, in the case of larger woven baskets, as cradles for babies. Woven containers were also a focus of traditional religious symbolism (there was a Woven Bag totemic clan, for example) and, because of their frequent use as gifts, they were an important medium for maintaining good relations between individuals and groups (Figs. 18,19).

The two main types of watercraft were the simple 'floating log', most frequently used during brief river crossings, and the messmate bark canoe. From the Archer River north, dugout canoes were made from the cotton tree and used for hunting sea turtle and dugong in the Gulf waters. Canoes were used on the inland lakes, swamps and estuaries during and just after the wet season, particularly for collecting eggs of the magpie goose, which are superabundant at that time, and for spearing fish. They were both paddled and punted. Figure 20 shows a canoe made and used for egg collecting in the Munpun area in the wet season of 1975-6, and then abandoned. That may have been one of the last traditional uses of a canoe in the region, as aluminium dinghies have become commonplace and store foods have increasingly replaced bush foods.

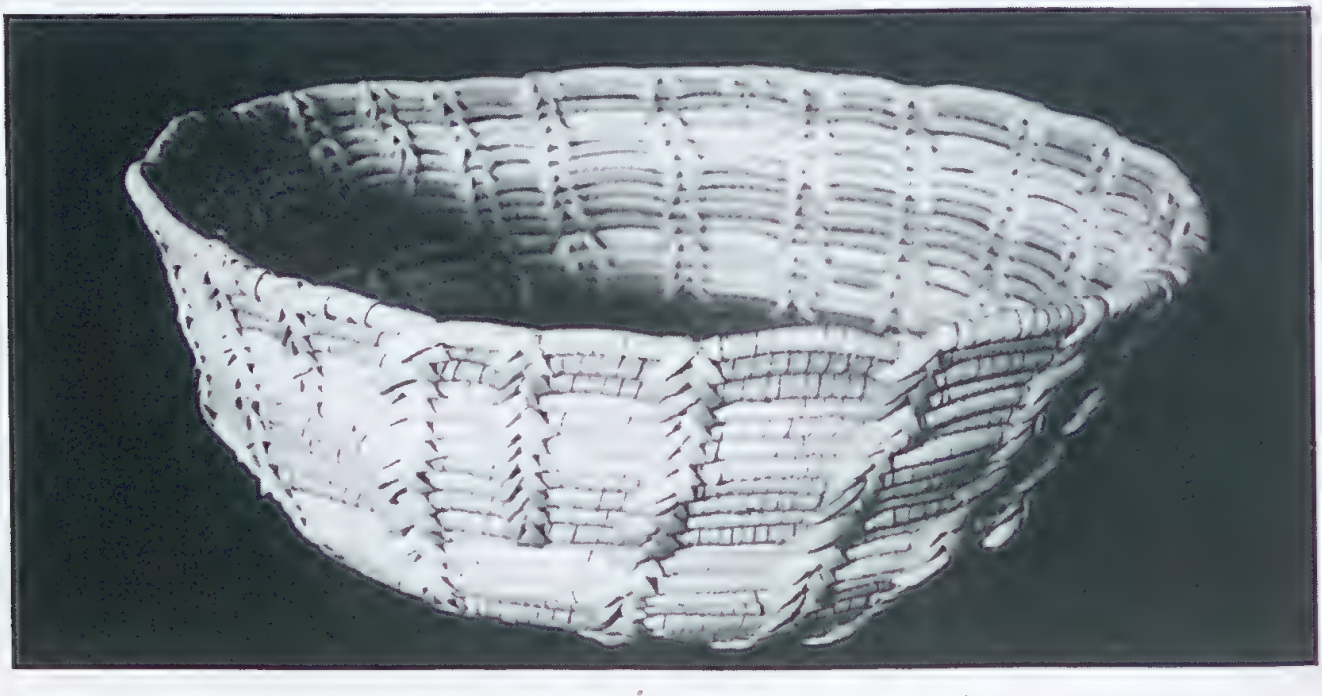

FIGURE 19. Basket made by Isobel Wolmby from Aurukun. Collected by P. Sutton, 1986.

FIGURE 20. Disused bark canoe near goose-egg swamps, Munpun 1976. Photo: Peter Sutton.

Fighting and duelling

Women fought with yamsticks and men fought with spears and spearthrowers, particularly if the conflict took place among those who had had time to prepare for this important aspect of individual and group relationships in the region. A 'false woomera' was also used by men - this was a spearthrower lacking a peg or baler shell ornament or both - and was used as a club. Spears for fighting at a distance were shorter and unbarbed. Long fighting spears were used for closer combat and for jabbing in the thigh as a means of settling grievances (see McConnel 1953: 25–6). Some of the spears specifically made for fighting had a cluster of stingray barbs at the nose, all pointing forward. These made an extremely painful and messy wound (Fig. 21). Men's clubs were either long and pointed, like yamsticks, or short, knobbed and pointed, and were used both for impact and for fending off spears (Fig. 22). The long throwing stick was also used to deflect spears. Shields were not used in this area. The proboscis of a sawfish or the teeth of a shark would be set in a handle of milkwood (*Alstonia actinophylla* (A. Cunn. A. Schum.)) to form a fighting sword. The conflict-related part of the material culture array in this region was clearly highly elaborated.

By the 1980s conflict was carried on primarily with fist-fighting and the opportunistic use of objects at hand which might be turned into weapons, such as pieces of fence, billycans, bottles,

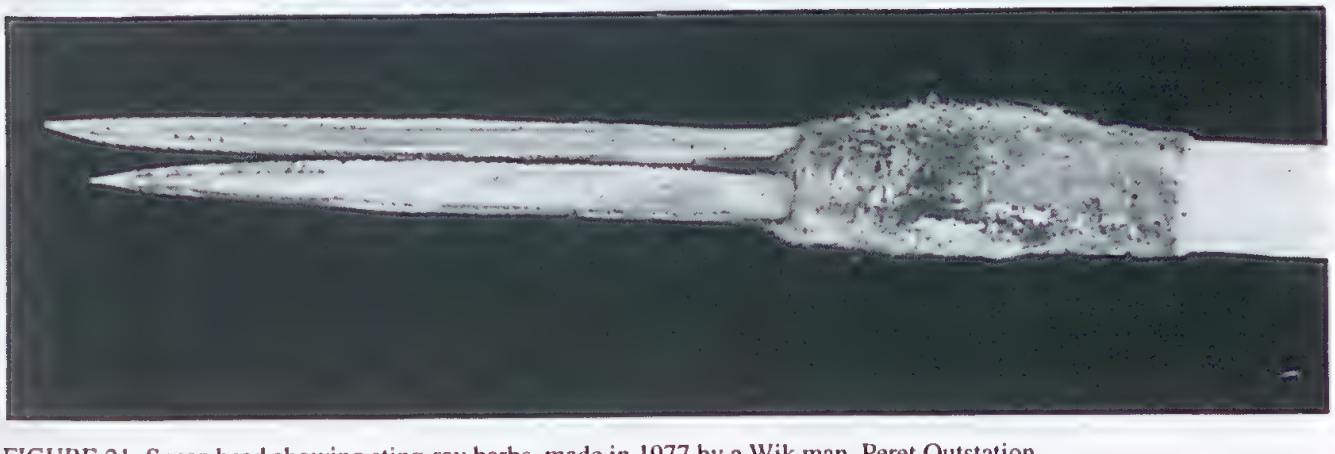

FIGURE 21. Spear-head showing sting-ray barbs, made in 1977 by a Wik man, Peret Outstation.

FIGURE 22. Two-pronged wooden club, decorated with seeds traded from Torres Strait, used to parry spears, Archer River, 1930s. Collected by U. McConnel.

broomsticks, steel knives and, occasionally, rifles or shotguns. By the early 1990s spearings had become rare.

Manufacturing technology

Tools used in manufacturing traditional artefacts included knives (originally made from shell, especially mudshell, or from bamboo, but latterly of steel), shell drills for boring holes in necklet shells, axes made of stone or steel, paired sticks used to tie the two sides of bags during weaving, bone awls used to pierce bark for canoe-making, wallaby incisors (still in the jaw) for cutting and graving, and a 'palette' or resin bat made of ironwood, with a wallaby incisor set in its handle, which was used for smoothing heated resin or wax and for engraving (Fig. 23). Woodrasps, saws, hammers and nails, heated wires, sharpening stones and butcher's 'steels' were all in regular use by a cross-section of Wik peoples by the 1970s. Carpentry and basic mechanics' skills were taught by missionaries and other community workers and a wide range of workshop tools were available in the main population centres from about the 1930s.

Magic and medicine

As in many parts of Aboriginal Australia, ironwood smoke (using the leaves of *Erythrophleum chlorostachys* (F. Muell. Baillon) in this case) was used to send away the spirits of the dead. After scraping, the roots of a fern (*Drynaria quercifolia* (L.) John Smith) were burned to yield a smoke which would send people into a deep sleep so one could, for example, steal away from one's family at night to engage in sexual activity. One could make oneself invisible (for example, when seeking

FIGURE 23. Ironwood palette used for smoothing heated wax and as an engraving tool, with wallaby tooth incisor attached. Collected by U. McConnel, Archer River, 1930s.

revenge) by tying one's upper arms with a string made from the roots of a fig (*Ficus virens* Aiton ex Dryander) or with the grass called *keent* in Wik-Mungkan (Family *Gramineae*). Rain could be prevented by burning the leaves of the whitefruit (*Eugenia eucalyptoides* F.Muell.), or by burning the roots and branches of the deciduous hardwood known in Wik-Mungkan as *yuk kuk* (possibly *Tinospora minasira*). Gamblers could improve their luck by secreting on themselves pieces of the bark of *Excoecaria parviflora* Muell. Arg., or of the 'crocodile-hand tree' (*Terminalia subacroptera* Domin.). These and other magical substances come under the same cover-term as materials used for both healing and sorcery in each of the Wik languages (for example, *operr*, Wik-Mungkan, and 'medicine' or 'bush-keymas [chemist]' in English, although the Pacific pidgin loan *purriy-purriy* is used for sorcery items).

Magical procedures in this region were complex, and too many to give in full here. One example is the transformation of wooden effigies or real specimens of small reptiles into live saltwater crocodiles which were then owned and controlled (and considered 'sons') by particular older men. The effigy or lizard would be bound with string and smeared with blood - preferably human - before being released into the water with appropriate exhortations. On returning to camp, the crocodile man (*pam thikel-kathenh*, 'man crocodile-ties' in Wik-Ngathan) must bring home very large pieces of firewood, not small ones, otherwise the crocodile would be undersized. These men are said to have called up their personal crocodiles and to have stood in the water with them, cleaning their teeth with a twig. The crocodiles could be sent to the river of another group to kill people. Deaths from crocodile were normally attributed to the malevolence of others.

Ceremonial life

Ceremonies in the area involve elaborate carvings made of wood, hair, bone and many other materials (see McCarthy 1964, 1978; Berndt, Berndt & Stanton 1981; Morphy 1981; Sutton 1988; Bartlett 1989). These are among the most spectacular sculptures in Aboriginal Australia.

While they are highly traditional in meaning, and carved and painted totemic wooden objects were collected from the region at the earliest stages of contact, in their present elaborate form the Aurukun sculptures appear to have flourished mainly since the advent of steel tools and the introduction of techniques such as morticing during the mission period in the present century (see McCarthy 1964: 300). These more technically complex works probably do not pre-date the late 1940s, when a major collection of them was made at Aurukun and lodged with the University of Queensland (now in the Anthropology Museum, Department of Anthropology and Sociology). The many examples filmed in ceremonial use at Aurukun by the Australian Institute of Aboriginal Studies in 1962, and collected by Fred McCarthy, are now in the National Museum of Australia (Dunlop 1964, McCarthy 1978). Although they were still being made for ceremonies in the 1990s, and some had been given to outside individuals or institutions (such as the South Australian Museum), only rare examples were allowed to reach the market.

These sculptures are used in regional cult ceremonies, a highly competitive form of religious celebration in which events from local mythologies are enacted by dancers to the accompaniment of songs and symbolic cries. They are, among other things, statements about rights and interests in specific places. They refer to the mythic 'title deeds' of Aboriginal customary law, and their making and use in performance by particular people wearing particular body-paint designs have strong local political and territorial meanings, as well as spiritual and aesthetic aspects. They may be spiritually dangerous for some time after their manufacture and are usually allowed to rot away in the bush.

Most Aurukun sculptures are figurative representations of particular beings in the myths, and are generally long and gracile, ranging from around 400 mm to over two metres in length (published illustrations are in e.g. McCarthy 1964, Morphy 1981, Berndt, Berndt & Stanton 1982, Sutton 1988). They are painted in non-realistic bands and patches of colour, and show a distinctive degree of trouble taken to insert realistic (and sometimes real) teeth, spines, tails and fins into the figures. They lack the smooth, static formalism and inscrutable stolidity of a good deal of the carving associated with some other so-called tribal societies. They have a stark, unpredictable and dramatic look which appeals especially to lovers of modernist 'primitivism'.

More restricted ceremonial material cannot be reported on here (cf. McConnel 1953), but it is appropriate to note that, according to initiated men alive in the 1970s, a previously unreported drone tube was in regular use at initiation ceremonies up to the late 1960s, although none have been collected to the author's knowledge. Percussion accompaniment to singing was mainly done by clapping. Saliva was regularly licked onto the hands to increase the clapping volume. Performers wore iridescent pendants cut from mother of pearl or nautilus shells, which were smeared with red ochre. They also wore filaments of white cockatoo feathers joined at the stem with a resin/wax mixture,

armbands of red-ochred pandanus, and sometimes armbands and girdles made from bark studded with red *Abrus* seeds. Some of these ornaments were also used in daily life.

When performing 'Island Dance', a dancing and singing style based on an amalgam of Pacific Island traditions with those of Cape York Peninsula, dancers in recent decades have worn and carried matchbox bean rattles, and sported colourful cotton *nagas* (loincloths) or synthetic grass skirts. Rhythm for this style is provided by hand-drumming on a membrane stretched over the end of a wide cylinder (often an inner tyre tube on a length of plumber's polythene pipe), or by beating of sticks on a metal flour drum. In the earlier part of this century, cylindrical drums were only used north of Archer River (McConnel 1953: 23). By the 1980s women had added a very erotic version of Polynesian hula dancing to their repertoire, which required flowers in the hair, leis, and brightly coloured synthetic grass skirts (Lurex is desirable). But hula here is only performed at mortuary ceremonies.

Personal adornment

Before adopting western dress, Wik people basically went naked, although women wore string aprons for symbolic or ritual reasons at certain times (see McConnel 1953: 15). People did wear many ornaments though, including pendants of shell and

FIGURE 24. Widow's necklet, with beeswax pendants studded with *Abrus* seeds. Collected by U. McConnel, Cape York Peninsula, 1930s.

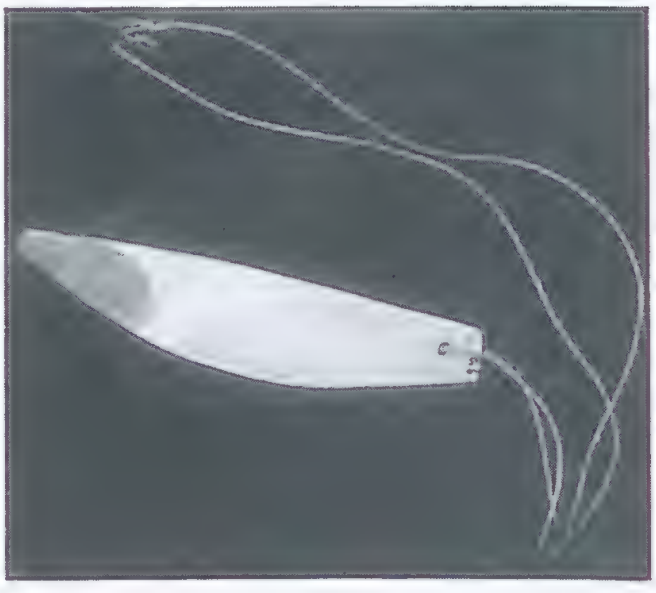

FIGURE 25. Shell pendant made by George Sydney Yunkaporta, 1977, Watha-Nhin Outstation. Collected by P. Sutton.

beeswax, shell nosepegs and wooden earlobe cylinders, strings and girdles of hair, fur, feather down, orchid-bark, palm fibre string, fig pneumatophore string, and threaded cowrie shells, pearlshell pieces, grass-bugles and *Abrus* seeds (Figs. 24,25). These adornments reflect an aesthetic preference for white and shining objects, or red objects. White clay and red ochre are also the dominant colours of ceremonial body paints in the region.

Aboriginal footwear is usually associated mainly with desert groups, but this author has been told on reliable authority that Wik people in the past did make grass and string sandals. Anyone who has tried to walk on the region's hot dry sands in bare feet will understand why this may well have been so. Local languages have an autogenous term for footwear (tha' morrok) which may have originally referred to the sandals but now refers to shoes and boots.

Drugs

Thomson (1939b) came to the view that tobacco had been available, but not grown, in Cape York Peninsula for a very long period before his first visit there in 1928. He reported three kinds of smoking pipe. One was a long cylinder, usually of bamboo or ironwood, open at one end into which someone smoking a cigarette or pipe expelled smoke which was at the same time inhaled by someone else through a small hole near the other end. Another was a short, broad cylinder of bamboo or ironwood which was filled with smoke then passed around to others who inhaled and exhaled the same smoke

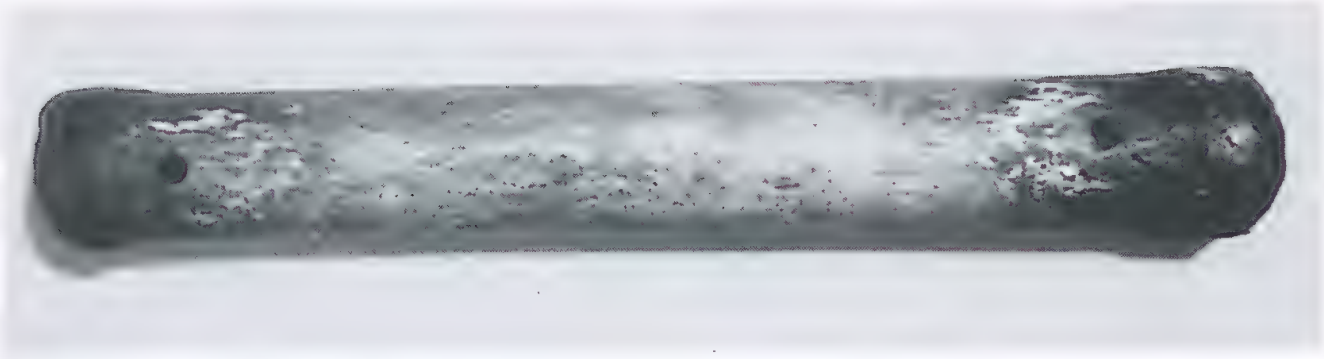

FIGURE 26. Communal smoking-pipe, collected by U. McConnel, Archer River, 1930s.

(Fig. 26). The third was modelled after the English briar-pipe, made of a very hard species of wood, and bored out with a hot wire. This last type was the only one still in regular use among the Wik peoples by the 1970s, although cylinder pipes were still made for the Aurukun craft shop.

Material culture today

At the present time most Wik people live for most of the year in modern Queensland-style houses or the tin sheds of outstations, and move about by Toyotas, cars, planes and tractors or motor-powered boats and, occasionally, horseback. Television sets and videos have become common possessions. Some Aboriginal households have acquired telephones. While traditional ceremonies are maintained in an attenuated form, Island Dance, hula and rock'n roll have become more frequently performed. The dead are no longer mummified, carried about for long periods or cremated at elaborate ceremonies, but are buried with a simple Christian rite and their houses ritually 'opened' by a mixture of traditional totemic and modern secular performances. Their spirits are still ritually sent to their homelands and their names are still prohibited from public use for a period after the death.

By the 1980s, the Wik economy had become based largely on welfare payments and limited local employment on community services, although fish, pigs, crustaceans and water birds still provided significant proportions of the diet. Alcohol had become a major economic and social preoccupation. Rifles, shotguns, nylon fishing lines and steel hooks had replaced most kinds of traditional hunting equipment, although the multi-pronged wire spear and spearthrower were still used for shoreline hunting. A number of bush medicines were still used, but constant use was also made of western medicines obtained through community hospitals and health workers. Many traditional items of material culture, and some objects introduced by missionaries (such as feather flowers and pandanus place-mats and bowls), were still made, however, either for the cash available from the craft outlets (see Adams 1986), or for gifts within the community.

Acknowledgments

My chief debt is to the people of the Cape Keerweer region, especially the residents of Watha-nhiin and Aayk Outstations in the years 1976–1979. Noel Peemuggina, Isobel Wolmby, Ray Wolmby, Clive Yunkaporta and Peter Peemuggina were my main informants on the specific matters dealt with here. I also wish to thank Dermot Smyth for making the botanical collections and for his cheerful company over many weeks of arduous field work. Dermot Smyth and The Queensland Herbarium provided the botanical identifications. I thank the South Australian Museum for permission to reproduce Figures 3–8, 10, 12–14, and 18, and the Museum's photographer, Trevor Peters, for Figures 11, 19, and 21–26.. Funding for field work was provided by The Australian Institute of Aboriginal and Torres Strait Islander Studies, the Australian Department of Education, and the University of Queensland.

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THE CHOOLKOONING 001 METEORITE: A NEW (L6) OLIVINE-HYPERSTHENE CHONDRITE FROM SOUTH AUSTRALIA

M. ZBIK & A. PRING

ZBIK, M. & PRING, A. 1994. The Choolkooning 001 meteorite: a new (L6) olivine-hypersthene chondrite from South Australia. *Rec. S. Aust. Mus.* **27**(1): 53–56.

The Choolkooning 001 meteorite is a single stone of 1.977 kg found approximately 63 km north of Hughes, South Australia, in 1991. It has been classified as an L6 chondrite shock facies S3–4 and contains olivine ($Fa_{24.7}$), orthopyroxene ($Fs_{20.5}$), plagioclase ($An_{12}Or_{6.2}Ab_{81.8}$), clinopyroxene, nickel-iron, troilite, chlorapatite and chromite. Mineral composition and textures indicate that Choolkooning 001 was a metamorphosed part of the L-planetoid and was moderately shocked before reaching Earth.

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A single mass of the Choolkooning 001 meteorite, now in several pieces, was found by an unknown collector, 30 km west of Choolkooning Rockhole and 63 km north of Hughes on the South Australian part of the Nullarbor Plain. The approximate co-ordinates for the site are 29°55'S, 129°50'E. The broken and weathered fragments, total mass about 2 kg, were illegally collected and exported to the United States of America in 1991. The meteorite was purchased in the United States of America by an Australian mineral dealer, Mr Robert Sielecki, who surrendered it to the South Australian Museum upon his return to Australia in March, 1992.

In recent years the Nullarbor Plain has proved to be a productive area for the recovery of meteorites (Bevan 1992; Bevan & Binns 1989a, 1989b) and in the last few years has attracted the attention of illegal meteorite collectors. Under legislation enacted by the Governments of Western Australia and South Australia all meteorites found in these states are the property of the Crown. An unfortunate consequence of the illegal trade in meteorites is the loss of important information on the exact date and location of the find. The locality given for the Choolkooning 001 meteorite by the dealer from whom Mr Sielecki purchased the stone was 100 km north east of Deakin, Western Australia. This places the find site within South Australia, approximately 63 km north of Hughes, some 30 km west of Choolkooning Rockhole (Fig. 1). In accordance with the guidelines on the nomenclature of meteorites from the South Australian Nullarbor (Bevan & Pring 1993), the meteorite has been named Choolkooning 001, being the first meteorite to be recorded from the Choolkooning area.

Physical Description

The meteorite is in eight fragments which range in size from 5 cm in length up to 20 cm. Four of the fragments fit together to form an incomplete rounded stone, two other fragments also appear to be part of this stone, but the other two fragments may be pieces from another mass of the meteorite. It is clear that several fragments are missing and it is not possible to say with certainty whether the meteorite was originally one or two stones.

Each piece shows a dark brown 1 mm thick fusion crust on at least one surface. The stone is heavily weathered displaying iron staining of silicate minerals and fractures filled with iron oxides. The broken surfaces of the fragments are also heavily weathered and the fusion crusts of some fragments are encrusted with calcrete, indicating that the meteorite had been exposed to the weather for many years. The interior of the meteorite is grey in colour and medium to fine grained.

In thin section the meteorite is generally light coloured with heavy iron oxide staining in some patches (Fig. 2). The chondrules are recrystallised and have poorly defined boundaries but are recognisable under crossed polars. They are typically 0.5 mm in diameter but some measuring up to 4 mm in diameter were also noted. Metal and troilite occurs as finely disseminated grains throughout the matrix. One piece of the meteorite was cut and the surface polished, and a polished thin section was also prepared and used for petrographic examination and in electron microprobe analyses.

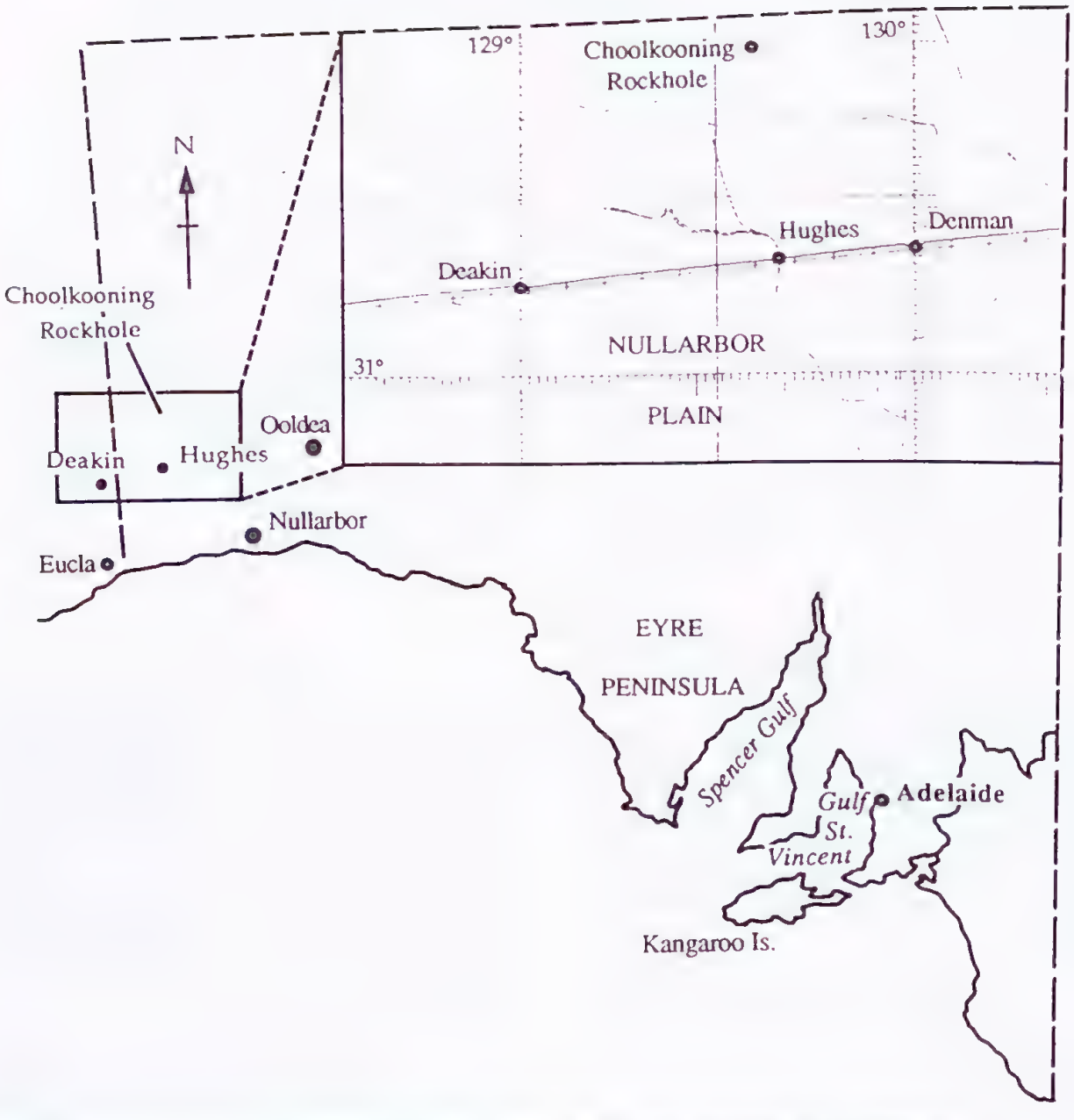

FIGURE 1. Map of South Australia showing the approximate location of the Choolkooning 001 meteorite.

TABLE 1. Average chemical compositions of major minerals in the Choolkooning 001 meteorite.

oxide	weight % olivine	orthopyroxene	plagioclase
SiO_2	39.1	54.1	63.8
TiO_2	0.1	0.2	0.1
Al_2O_3	0.1	0.1	21.0
FeO	22.8	14.7	0.6
MnO	0.5	0.5	0.1
MgO	38.8	28.8	0.1
CaO	0.1	0.7	2.3
Na_2O	–	–	8.5
K_2O	–	–	1.0
Cr_2O_3	0.1	0.1	–
NiO	0.1	0.1	–
Total	101.7	99.3	97.5

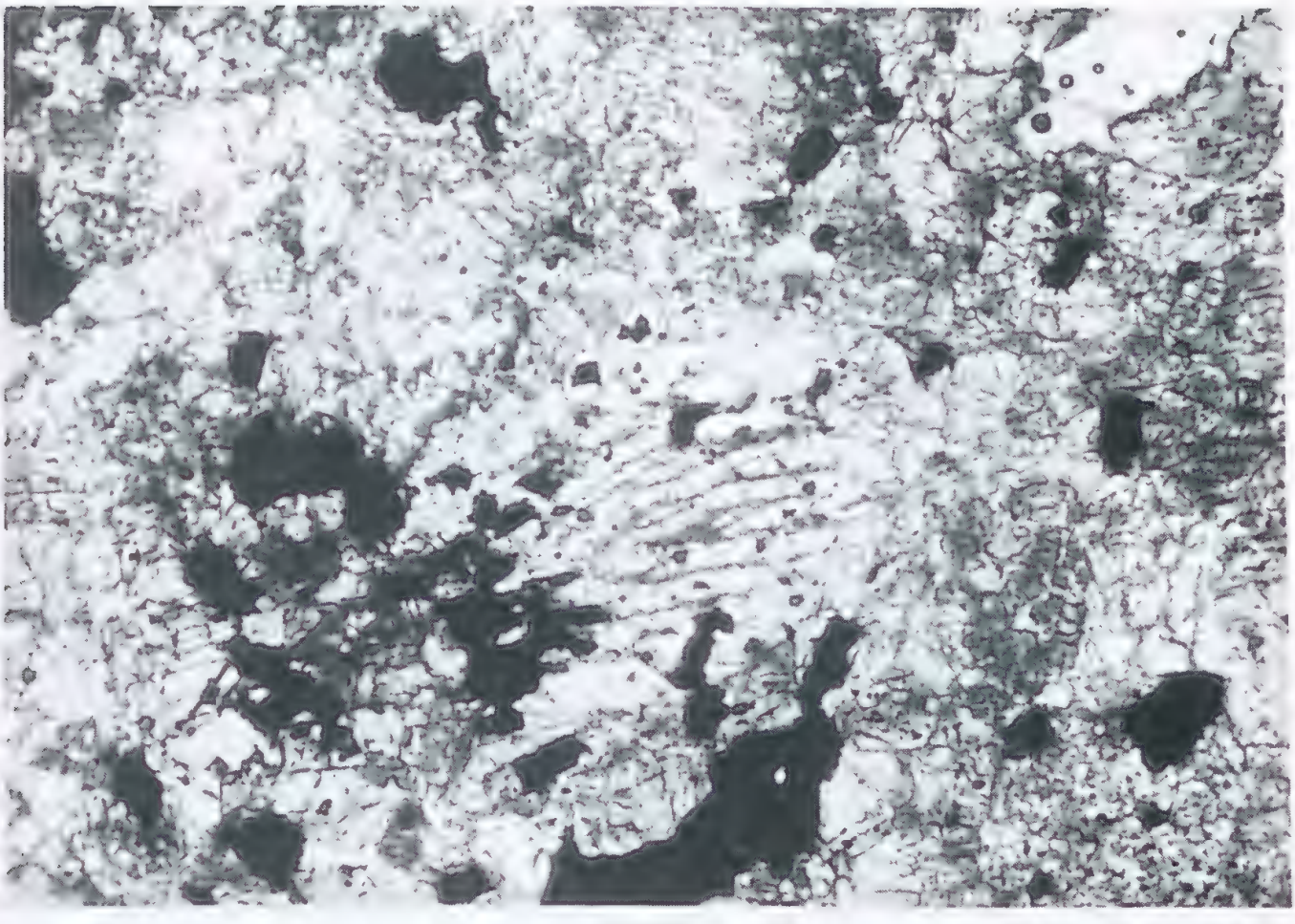

FIGURE 2. Photomicrograph of the Choolkooning 001 meteorite in thin section showing typical fractured olivine grains in the recrystallized matrix.

Mineralogy

Compositions of the silicate minerals were determined with a JEOL electron microprobe at the University of Adelaide Centre for Electron Microscopy and Microbeam Analysis. Analyses were made using an accelerating voltage of 15 kV, a sample current of 3 nA, and a beam width of 5 μm. Representative mineral analyses are presented in Table 1.

Relic chondrules and chondrule fragments are composed predominantly of olivine, with lesser amounts of orthopyroxene. 'Barred' chondrules composed of olivine and orthopyroxene also have thin lamellae of either clinopyroxene or plagioclase. The matrix consists of olivine and orthopyroxene grains with very rare grains of clinopyroxene up to 20 μm in diameter. Plagioclase is abundant throughout the matrix as small turbid grains which display undulate extinction. Coarser (up to 500 μm) grains of plagioclase feldspar also occur in the matrix with some exhibiting albite twinning. Nickel-iron metal, troilite, chlorapatite and chromite occur as accessory minerals.

Microprobe analyses show that the olivine in the Choolkooning 001 meteorite is equilibrated with a mean fayalite content of $Fa_{24.7}$ (range $Fa_{23.8–25.4}$, 30 analyses). The orthopyroxene shows only a small variation in chemical composition with a mean ferrosilite content of $Fs_{20.5}$ (30 analyses) and a wollastonite content of 1.5 mol%. Clinopyroxene was identified but the grains were too small to provide reliable analyses. The plagioclase content was found to be $An_{12}Or_{6.2}Ab_{81.8}$ (11 analyses).

The pyroxene geothermometers of Wells (1977) and Lindsley (1983) suggest that the Choolkooning 001 meteorite was heated to temperatures of between 700° and 800° C during metamorphism while the meteorite was still part of a large L type asteroid. The Choolkooning 001 meteorite is very similar in composition to the Mangalo meteorite, an L6, recently described from Eyre Peninsula (Wallace & Pring 1991).

Classification

The Choolkooning 001 meteorite has been classified as an L6 chondrite. The olivine composition is within the range of the L chondrites (Keil & Fredriksson 1964), and the orthopyroxene composition ($Fs_{20.5}$) shows that the meteorite

belongs to the olivine-hypersthene chondrite group. The highly equilibrated chemical composition, crystalline matrix, poorly defined chondrule boundaries, well recrystallized plagioclase and euhedral chlorapatite crystals suggest that Choolkooning 001 belongs to the type 6 classification of Van Schmus & Wood (1967). The wollastonite content in the orthopyroxene is similar to that found in most L6 chondrites (Scott *et al.* 1986). The presence and content of plagioclase, the degree of crystal fracture and the undulate and mosaic extinction with planar fractures all indicate that the meteorite has been moderately shocked after metamorphism. According to the classification scheme of Stöffler *et al.* (1991) the shock facies is estimated to be S3–4, moderately shocked.

Acknowledgments

The authors wish to thank Mr G. Horr for preparing a polished thin section of the meteorite and Mr Huw Rosser of CEMMA, University of Adelaide for assistance with the electron microprobe analyses. The financial support of the Ian Potter Foundation and the Friends of the South Australian Museum is gratefully acknowledged. We also wish to thank Dr. Alex Bevan and Dr. Margaret Wallace for their constructive comments on the manuscript.

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OBITUARY

SHANE ALWYNE PARKER

3 August 1943 – 21 November 1992

This obituary gives emphasis to Shane's work in marine invertebrates and lists all his publications. His ornithological work was emphasised by Horton (1993).

Shane Alwyne Parker was born in Colchester, Essex where he attended schools gaining his O-Level in seven subjects. His interest in natural history developed early with walks in the English countryside with his aunt. He was an obsessive collector with an inquiring mind and often visited the Colchester Museum to identify natural history specimens that he had collected. Sadly, Shane's father did not approve of this "obscure" interest and, as Shane related to me, his life at home was not a happy one. At the age of 16 he began work at the British Museum, at Bloomsbury, initially as assistant in the Photographic Section, Reading and Map Room and later as assistant in the Bird Section of the Natural History Museum. He used to travel on the train from Colchester to London and back every day, leaving home at some ungodly hour each morning. Sometime later he moved to London and lived in a hostel where he obviously had a very merry time. He spent six and a half years at the British Museum, three as curator of their egg collection. In 1964 he took part in the second of the Harold Hall (British Museum) expeditions in Australia to northern Queensland from February to August. Those seven months were a highlight in Shane's life and influenced him to emigrate to Australia in 1967.

From 1967 to 1971 Shane worked for the Arid Zone Research Institute, Alice Springs, first as assistant to the Biologist and then to the Botanist, taking part in faunal and floral surveys of the Northern Territory and curating zoological and botanical collections. During this period (January – March, 1968) Shane undertook a solo trip to Choiseul and Malaita, Solomon Islands, in search of a species of ground-pigeon, without success (40). Later, working on a wallaby survey (39), he moved to Darwin where he met his future wife, Erica, whom he married in 1970 in Alice Springs. They moved to Adelaide in 1971 where Shane, feeling the need for a formal education, studied full-time at Daws Road High School to gain his Matriculation in 1972. He went on to complete a Bachelor of Science degree, majoring in Botany and Zoology, at the University of Adelaide in 1975.

During all this time Shane's lack of formal qualifications did not prevent him from publishing his observations. He published his first paper at the age of 16 (1) and by the end of 1967, while at the British Museum, had published 24 notes and articles, probably embarrassing some of his colleagues who encouraged him to emigrate. During his early years in Australia he continued to publish ornithological observations, corresponding regularly with other workers in Australia and overseas and while in Adelaide became an Honorary Research Worker at the South Australian Museum. When Herbert Condon retired as Curator of Birds in late

1974 Shane, while completing his final year at University, was asked to run the Bird Section until a replacement could be found. By this time Shane had published a further 25 articles including one on plants (38) and two on mammals (39, 47), the latter publication being a significant contribution. Logically and fittingly Shane was appointed Curator of Birds in January 1976 – a position which he held full-time until 1985 when he began his work as Curator of Lower Marine Invertebrates. This dual role continued until October 1991 although his work in ornithology consisted mainly of completing small research projects and training Dr Philippa Horton to take over the management of the Bird Section, the position of 'Curator of Birds' having been abolished. Tragically, by this time, Shane had been diagnosed with a lymphoma and although initial treatment seemed successful he lost his fight of about two years and died peacefully at home on 21 November 1992.

During his relatively brief lifetime Shane published some 118 notes and articles (including seven book reviews), more than 100 of them on ornithology. There is no doubt that Shane's knowledge of birds of the world and the Australasian bird fauna in particular was highly regarded worldwide, and it was for this reason that he was chosen as one of only five Australian delegates to visit China in 1981 under the auspices of the Australian and Chinese Museums Association (83). He was an active member of the South Australian Ornithological Association serving as Vice President in 1979–81 and 1985–86. He also served the Royal Australian Ornithologists Union as Councillor (1978–81), Chairman, Record Appraisal Committee (1979–82) and on the Taxonomic Advisory Committee (1979–83); and in 1978–81 he was on the Conservation Programme Committee of the World Wildlife Fund (Australia). He was also Secretary for the Royal Society of South Australia for the year 1986–87.

Amongst ornithologists Shane will best be remembered for his contribution to the Museum's bird collections. With the help of a dedicated band of volunteers, which he cultivated, Shane began the process of modernising the collection. Almost from scratch he began to establish parallel collections of skeletons, whole spirit specimens, nests and stomach contents. He conducted field work mainly to collect downy young and immatures of non-passerines, domestic species and neglected common species, and further augmented the collection and filled in gaps by exchanges with other museums. As a result of those activities the bird collections increased dramatically in size and scientific significance. In a relatively short time Shane, with his acquisition program and meticulous documentation, had transformed the Museum's bird collections from one used mainly by bird watchers to one of science. He was always generous with his time making himself and the collection very available to bird enthusiasts and spent many hours encouraging young people to develop their interest in and knowledge of birds. Many of these people are now employed in the field of natural science and environmental studies. A highlight of his curatorship was the good relationship which he cultivated with the descendants of Captain S. A. White resulting in the donation to the Museum of White's African bird skin collections in 1976 and the main skin and egg collection in 1988. Shane's relationship with the White family culminated in the Museum's exhibition 'Captain White and the House of Birds'. Regrettably he died only 24 days before the exhibition opened.

Shane delighted in detective work, whether it was unravelling details of historical collecting expeditions and collections (18, 71, 91, 92, 108) or taxonomic problems (42, 88, 90). He also loved searching for 'lost' species (40, 62) and in 1979 joined an expedition on camel to search for the night parrot around Cooper's Creek. He believed as the only known specimens were discovered on camel he was more likely to succeed by these means if the bird was still extant. The party sighted four birds east of Lake Perigundi but Shane was not entirely convinced and never published a detailed account of the observations.

For his ornithological work Shane was honoured by the naming of a new subspecies of Honeyeater, *Acanthogenys rufogularis parkeri* (Parkes 1980) and two species of feather louse from the mallee fowl (Price & Emerson 1984; Emerson & Price 1986). On the latter Shane remarked "to the delight of my friends and the even greater delight of my enemies!". Although his career in Marine Invertebrates was brief he touched many with his enthusiasm, clarity of thought and meticulous research and his memory will be honoured by the naming of several species by various colleagues in future publications.

During the early 1980s Shane had some unfortunate disagreements with a few amateur ornithologists and his over-sensitive nature led him into deeper conflicts than need have been. These arguments came to a head over the description of a new sandpiper (79) resulting in a prolonged conflict and threatened legal action by both parties. These events were particularly distressing for Shane as he prided himself on his honesty and integrity and it hurt him deeply when he did not receive the support from his colleagues that he might have expected. In addition Shane was facing ill-informed criticism from a few amateur ornithologists and the public for the collection of specimens, particularly in regard to the Eyrean grasswren. Shane ultimately became very

disillusioned with the Australian ornithological community and in 1985 he switched his energies to the much neglected lower marine invertebrates.

Observing Shane working in the Marine Invertebrates Section was like watching a child with new found toys. There were just so many areas where he could apply his love for classical taxonomy. To his surprise and delight he found that new species could be found almost on a daily basis and new genera and families lurked in the collection or amongst newly acquired material from deep-sea trawlers.

Confronted with an array of animal groups, some of which he didn't even realise existed, he quickly sought out experts and corresponded with them. Much to his surprise he found them only too willing to help and share information. He corresponded often and developed a relationship with some colleagues that resulted in several joint publications describing the fauna of southern Australia. One of his major articles, and one of which he was justifiably proud, was a monograph on the stony corals of South Australia, Victoria and Tasmania which he produced with S. D. Cairns of the Smithsonian Institution as senior author (111). It was his last paper to be published before his death. Shane also published on polychaetes and bryozoans and at the time of his death was working on a couple of papers on leeches.

I was continually amazed by Shane's ability to comprehend the complex systematics of some phyla, if only to come up with a scheme of classification so that he could properly curate the collections. He very quickly identified specimens as best he could, completely reorganised the collections and curated them according to the most modern, acceptable classification. Whenever he came across a group for which he could not find an acceptable scheme of classification, he would write to one of the experts, usually overseas, and ask for help. Often this kind of correspondence led to the material being loaned for study, resulting in publications describing the unique fauna of southern Australia. Shane encouraged the use of the collections by others and was very generous with his time, often humbly accepting junior authorship for his efforts. He organised many exchanges of specimens and added substantially to the literature base of the collections. Shane was rewarded for his curatorial efforts when an overseas colleague, in a submission to the Museum Review 1991/92, remarked 'I have worked extensively at the U.S. National Museum, Smithsonian Institution and also at the British Museum and the collections at the South Australian Museum are far superior in quality'. These remarks and ones in a similar vein from other colleagues pleased Shane very much.

Shane soon came to realise that he could not do everything and I encouraged him to specialise in polychaetes or bryozoans. It was the latter group that eventually 'grabbed' him and he was continually amazed by the diversity and beauty of the little 'critters'. Shane was never anyone to do things by halves and even when he was ill he was working on his checklist of Australian bryozoans which was to form the basis for future major taxonomic revisions of the entire Australian fauna. Fortunately for bryozoan workers Shane's checklist will be completed by his colleague and collaborator, Dr Peter Haywood, University of Wales, Swansea. But sadly, a wealth of knowledge passed away with Shane and we will never know the greatness that he was sure to achieve.

To some people, particularly to those who did not know him well, Shane was an English eccentric born about a century too late. He was a great admirer of Conan Doyle's hero, Sherlock Holmes and in winter often wore a tailor-made Edwardian frock-coat and wing collars. Although Shane loved elegant and stylish clothes, particularly the Edwardian fashions, and may have admired the life style of Edwardian society, that did not necessarily make him old fashioned. He was quite up with modern technology and methods and was instrumental in the purchase of a Scanning Electron Microscope for the Museum and used the instrument regularly for his research. However, I think he may have been more comfortable with computers had they been steam driven. Shane was widely read especially in ancient history, natural history and exploration and had a broad and deep knowledge of a wide variety of subjects. He was skilled at languages, took lessons in Gaelic and taught himself Latin while commuting on the train so that he could read the classics in the original. He also enjoyed a good detective story and was partial to the obscure and bizarre with Dan Dare comics, Winnie the Pooh, Molesworth and 'William' books being some of his favourites. He was an acknowledged authority on bawdy English folksongs which he could sing well in the appropriate accent. His collection of songs is regarded by some as one of the best in the world, valued for its academic content as well as for the many rare and original versions. Shane also loved fine music whether it was classical or modern with Pachelbel's Canon in D being one of his favourites. He was a talented artist and purchased his first bird book with money from selling his bird paintings to relatives and friends. He was particularly good at caricature and comic strips which provided an outlet for his wonderful, unique sense of humour. He enjoyed working in his vegetable garden and amongst his many other interests was that of steam trains and collecting finely engraved stamps and cigarette cards.

Perhaps his greatest passion was that of good food and wine. He was sometimes 'caught' in his office devouring some great custard pie or cream bun. Yet these gastronomic excesses had little effect on his slight frame. In the Marine Invertebrates Section, cream buns or preferably, huge creamy cakes, were compulsory on birthdays and whenever a paper was published – we seemed to have rather a lot of those! Shane was a founding member and the driving force behind the Museum select dining club *De Gustibus* and was the editor of its occasional organ *The Gullet*. This gave him a wonderful opportunity to make use of his creative writing skills. He loved the English language and took great delight in using it. He spent hours over the articles and the presentation of *The Gullet* and kept copies of all the issues. Perhaps as a result of his trip to China in 1981, where he attended many banquets of duck's feet and other unmentionable or unidentifiable gastronomic delights, it was the charter of *De Gustibus* to dine out at unusual places and sample unusual dishes. The annual *De Gustibus* Christmas Luncheon was a grand affair. It was the duty of everyone attending to provide an exotic dish that they had prepared together with good wine and champagne. Shane would address the meeting apologising for the absence of our fictitious president Sir Gregory Parsloe-Parsloe K.B. (Shane's alter-ego) who was unable to attend because of some hilarious and often disgusting, gluttonous mishap. The whole proceedings were always accompanied by live chamber music with Pachelbel's Canon being played at the beginning and end. For me these annual events were some of the most memorable of my life and I am grateful to Shane for the experience. Members of *De Gustibus* will be pleased to learn that before his death Shane honoured Sir Gregory by the naming of an appropriately large bryozoan; let us hope it gets published before the editor finds out! I will miss his good humour and sharp wit and I will never forget his last words to me as he said with a mischievous smile and knowing glint in his eye 'See you anon old bean'.

To Shane's wife Erica and their sons Gathorne and Tolle we extend our heartfelt sympathy.

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PROCEEDINGS OF THE FOURTH CONFERENCE ON AUSTRALASIAN VERTEBRATE EVOLUTION, PALAEONTOLOGY AND SYSTEMATICS, ADELAIDE, 19–21 APRIL 1994.

INTRODUCTION

During the third Conference on Australasian Vertebrate Evolution, Palaeontology and Systematics, held in Alice Springs in 1991, delegates were asked to decide the venue of the next meetings two years thence. Rhys Walkley had reminded me that 1993 would be the centenary of the first expedition to Lake Callabonna. It therefore seemed fitting that Adelaide should host the 1993 meetings, and that in fact they should coincide with an exhibition about the Lake Callabonna fossils to be held at the South Australian Museum.

This offer was accepted, together with a non-exclusive theme of Plio-Pleistocene palaeontology, with Rod Wells (Flinders University of South Australia) and Neville Pledge (South Australian Museum) combining to organise the meetings and pre- and post-conference excursions. The organisers are grateful for the help given by Mr Gavin Prideaux in the program planning and printing of the abstracts.

The Conference was held in the Grosvenor Hotel, North Terrace, Adelaide, between 19–21 April 1993. More than fifty professionals, students and amateurs, several from overseas, attended to hear 49 papers read and to see eleven poster presentations. The student prize of an airline ticket to any Australian city for the purpose of study was donated by Australian Airlines. It was awarded to Ms Sanja Van Huet (Monash University) for her description of the Lancefield megafaunal site.

A five-day pre-conference excursion to Lake Callabonna and Lake Palankarinna drew 13 participants, and an *ad-hoc* excursion to Naracoorte had 20 people.

During the Conference the exhibition 'Fossils of the Lake' was officially opened by Dr Richard Tedford (American Museum of Natural History), a veteran of two major expeditions to Lake Callabonna. The author is grateful to all who helped make the Conference a success.

NEVILLE PLEDGE
Curator of Fossils,
South Australian Museum

FOSSILS OF THE LAKE: A HISTORY OF THE LAKE CALLABONNA EXCAVATIONS

NEVILLE S. PLEDGE

PLEDGE, N. S. 1994. Fossils of the Lake: a history of the Lake Callabonna excavations. *Rec. S. Aust. Mus* **27**(2): 65–77.

The discovery of *Diprotodon* fossils in Lake Mulligan in 1892 led to a major expedition by the South Australian Museum the following year. Initial reports indicated scores, if not hundreds, of skeletons exposed on the dry lake bed. Excavation showed the reality: most skeletons were incomplete and the bones badly eroded or rotten. Nevertheless, a large quantity of fossilised material was recovered, under trying circumstances, by the two-stage expedition, and returned to Adelaide. Preparation and repair of the bones took many years, and the first complete *Diprotodon* skeleton was unveiled in 1907. Other fossils included a new species of giant bird, *Genyornis newtoni*, the giant wombat *Phascolonus gigas* (which proved the synonymy of *Sceparnodon*) and several large extinct kangaroos.

Subsequent expeditions by R. A. Stirton in 1953 and R. H. Tedford in 1970 have thrown more light on this, Australia's first Fossil Reserve, a 'veritable necropolis'.

N. S. Pledge, South Australian Museum, Adelaide, South Australia 5000. Manuscript received 1 February, 1994.

In 1831, while exploring the Wellington Valley of New South Wales, Major Thomas Mitchell found a fragment of a large jaw in one of the caves (Mitchell 1839). He sent it to Professor Richard Owen in London for identification. Owen, the world's leading anatomist of the day, soon realised that it came from a gigantic new species of marsupial, which he named *Diprotodon*, for its pair of large protruding incisor teeth ('two forward teeth') (Owen 1839).

Over the next few decades, Owen described more and more bones of the skeleton of *Diprotodon* sent to him by collectors in Australia, and eventually (Owen 1870, 1877), he published a skeletal reconstruction of the animal. But he was continually frustrated by the lack of associated footbones and he died in December 1892 without knowing their complex structure, only months before discoveries of complete skeletons would be made.

In 1870, a reward of £1 000 was offered for the discovery of a complete *Diprotodon* skeleton, and in the 1880s the discovery of skulls at Gawler (Howchin 1891) and Baldina Creek near Burra (Zietz 1890a), and associated bones at Bundey on the Murray Plains (Zietz 1890b), raised hopes that success would be attained. When word reached Adelaide in November 1892 that *Diprotodon* bones had been found on 'Mulligans Lake', north of Lake Frome, excitement swept the colony.

Geomorphology and geology

Originally called Lake Mulligan, Lake Callabonna is one of a chain of large dry saltpans (Fig. 1) that form a horseshoe around the northern Flinders Ranges from Lake Torrens to Lake Frome (Stirling 1894).

On the site of an ancient silted-up lake system (Callen & Tedford 1978), modern Lake Callabonna has been formed by deflation: the wind blowing dried salt, sand and clay particles to the east and north to form the Strzelecki Desert. In earlier times, the lake was considerably larger and intermittently full of fresh water (Tedford 1993). Stranded beaches may be found kilometres from the present shoreline.

During the Pleistocene, when the *Diprotodon*-bearing Millyera Formation was deposited, there was a fluctuating water level, as indicated by cyclic couplets of sand and laminated clay, the sand often being ripple-marked (shallow water or dry conditions) or desiccation cracked (dry/arid conditions). But the absence of fish fossils suggests the water in which the clay was deposited was too shallow or ephemeral to support them. Pieces of wood, and cones of the native pine *Callitris* indicate a wooded shoreline (Tedford 1973). Today it is virtually bare.

Later a more permanent lake formed supporting a plentiful fish and mollusc population. The

FIGURE 1. View of Lake Callabonna, looking south from the hill behind the 1893 camp. Photo: attrib. H. Hurst. SA Museum Heritage Collection.

mound springs then formed islands in the lake and were used as safe nesting areas for waterbirds whose bones have been found, and dated between 2 000 and 3 000 years old. This may still occur today, such as during the floods of the early 1970s when the lake was full for several years. There is evidence that Aborigines sometimes visited these islands in search of food such as swans' eggs, since worked quartzite flakes have been seen on one of them, associated with bird bones and eggshell fragments (pers. observ.).

Human history of the area

Lake Callabonna falls within the sphere of the Pilatapa (Piladappa) Aborigines (Fig. 2) who occupied an area from Freeling Heights and Lake Frome to Lake Blanche and the southern part of the Strzelecki Desert, where an occupation site over 14 000 years old is known (Smith *et al.* 1991). Stone artefacts, including grinding stones possibly obtained from Prism Hill, south of Balcanoona, and polished stone axes (possibly traded from the east) have been found near the lake (pers. observ.). Ancient rock engravings are known in the Flinders Ranges. It is possible that the legendary '*Yamuti*' (Tunbridge 1988) of the nearby Adnyamathanha people is a folk memory of *Diprotodon* with which they could have been briefly contemporaneous, or at least a construction built on the knowledge of giant bones in the lake.

Robert Stukey named it Mullachon Lake in 1860, after the Aboriginal name for the mound springs on its western side. This soon became corrupted to Lake Mulligan.

The first European to see Lake Callabonna was Edward John Eyre in 1840. A few years later (1844), the lake was visited by Charles Sturt's party coming in from the east.

Pastoral activity started rather late, in the 1860s at Blanchewater. In 1882, John Ragless established his son Frederick B. (Fig. 3) on the Callabonna run, on the eastern side of the lake (Mincham 1967). In establishing the homestead (Fig. 4) Frederick Ragless found *Diprotodon* bones in a well nearby and these were sent to the South Australian Museum in 1885.

Discovery

The Aborigines had long talked of large bones on the bed of Lake Mulligan, but they had been thought to be of bogged horses or cattle (Ragless 1893, *South Australian Register*, 7 July 1893). On 12 June, 1892 Ragless had accompanied an Aboriginal stockman to an area on the lake bed to

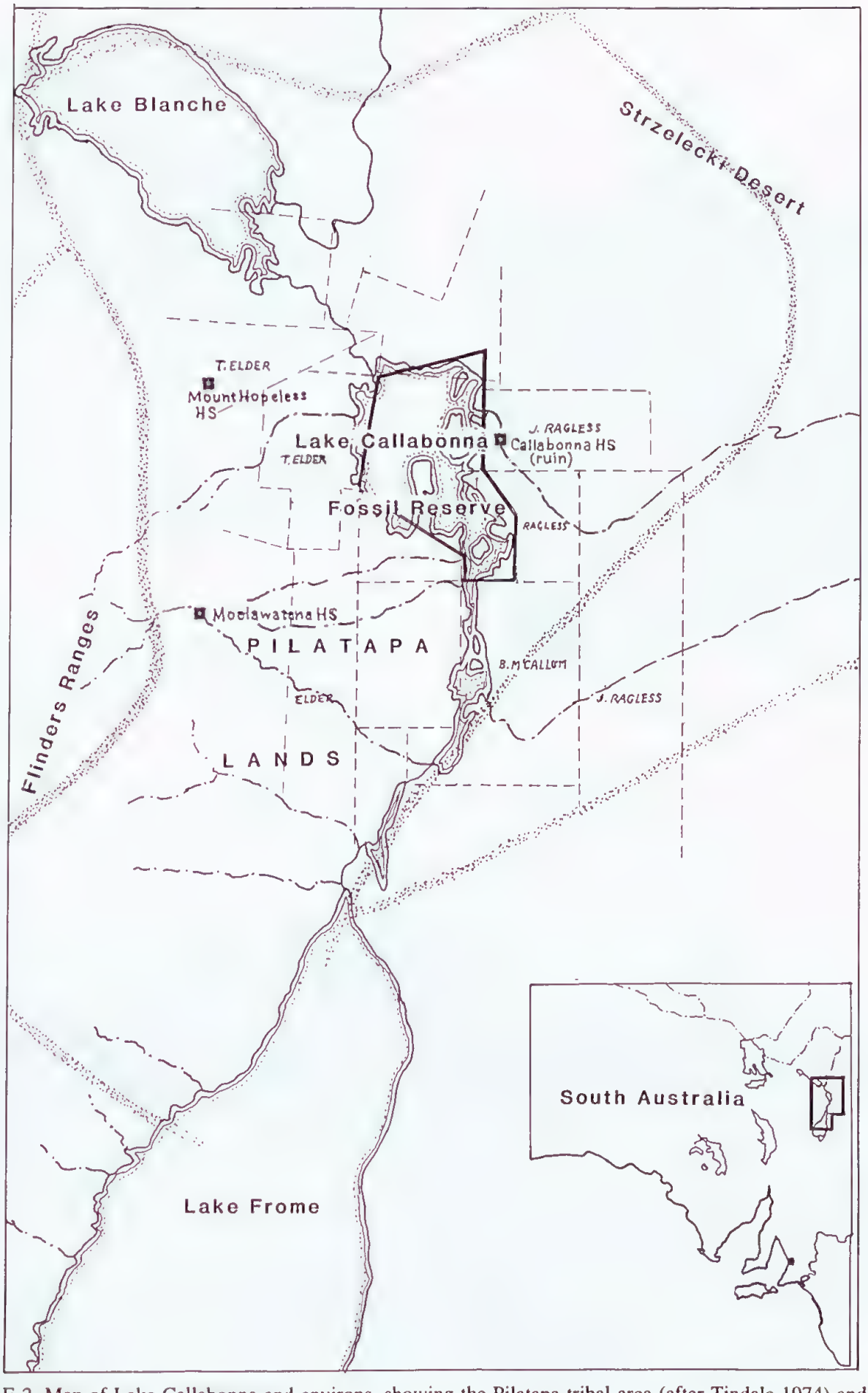

FIGURE 2. Map of Lake Callabonna and environs, showing the Pilatapa tribal area (after Tindale 1974) and some pastoral boundaries.

FIGURE 3. Frederick B. Ragless. Photo: courtesy L. Ragless.

see the bones (Fig. 5), following a conversation with the Aborigine a few days earlier when they had been talking about elephants. In his journal Ragless recorded that the boy, Jacky Nolan, had told him:

> I bin tinkit elephant alonga this country one time. Me bin see'em bones. Me show'em you big fella bone alonga lake. 'Im much too big alonga panto [horse] (Ragless, unpubl.)

Ragless collected some of the bones and took them back to the homestead to show his men, and planned to take them to Adelaide at first opportunity. One of the men, John Meldrum, persuaded Nolan to take him back to the fossil site where he made his own collection. Shortly afterwards Meldrum 'left the station and came to town, where he exhibited the specimens at Mr P. Lee's Black Swan Hotel, North Terrace and claimed to be the discoverer' (*South Australian Register*, Thursday 6 July 1893, p. 4). Discovery of the bones led to a dispute over the reward which was never really settled.

Meldrum's arrival in Adelaide (*South Australian Register*, Tuesday 4 November 1892) with bones from Lake Callabonna was seized upon by the local press who followed succeeding events avidly. The *Register* (2 December 1892, p. 5) reported that the South Australian Museum was

FIGURE 4. Callabonna Homestead, 1884. Photo: courtesy L. Ragless.

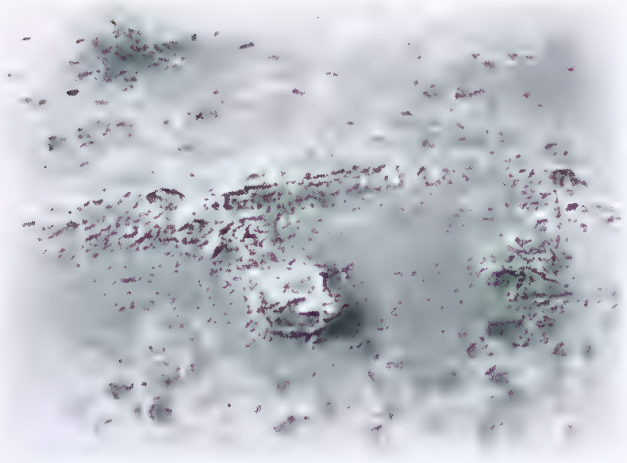

FIGURE 5. *Diprotodon* skeleton eroding out of the lake floor. Photo: attrib. H. Hurst. SA Museum Heritage Collection.

sending Henry Hurst to investigate the site. He left on 2 December 1892 and returned on 5 January with great news.

1893, Phase 1

Hurst's favourable report to the Museum Board was enough for them to send him back with a larger expedition and more detailed instructions.

Henry Hurst had worked for the Queensland Geological Survey and had collected fossils of *Diprotodon* etc. from the black soils of the Darling Downs, so he seemed well suited to lead the expedition which left on 13 January for three months to conduct systematic searches and excavations for *Diprotodon* specimens. With him he took his brother George, John Meldrum, two labourers, and an Afghan to handle the camels and bring supplies. The party travelled by rail as far as Farina (409 miles/658 km), where they obtained camels and horse and buggy (Fig. 6) to go around the north end of the Flinders to Lake Mulligan/Callabonna. This last stage of 200 miles (320 km) took eight days to travel.

Hurst set up camp on an 'island' a couple kilometres from the edge of the lake bed, but after three weeks subject to the full force of the prevailing winds, moved it permanently to the western side of this island (Fig. 7). Excavations started at the spot first pointed out by Meldrum, but these specimens proved to be much decayed. Hurst used them, however, to instruct and train his inexperienced workers.

Hurst's reports to Stirling were initially sent every few weeks and were extravagant in their description of the deposit and his results. Later they dealt more with the problems encountered – irregular and late mails and shortage of feed and stores (Figs 8, 9) due to rains, requirements for

FIGURE 6. Hurst's party about to leave Bruce's Hotel, Farina, with camel team and buckboard, 1893. Photo: attrib. H. Hurst. SA Museum Heritage Collection.

FIGURE 7. Permanent camp, Lake Mulligan 1893. Photo: attrib. H. Hurst. SA Museum Heritage Collection.

FIGURES 8,9. All supplies were brought in by camel from many kilometres away. **8**, water; **9**, firewood. Photos: attrib. H. Hurst. SA Museum Heritage Collection.

sending the bones back to Adelaide and impending deadlines for the return of the camels and the cessation of the expedition. Hurst did, however, send accurate reports of new discoveries, such as the footpad impressions associated with the *Diprotodon* foot bones (letter, 16 March 1893), and the partial skeleton of a giant 'struthious' bird (letter, 6 May 1893), later to be named *Genyornis newtoni*. His excitement about the latter was such that he telegraphed the news of its discovery to Stirling. There was also a fossilised fruit, found near the bird remains, which he sent to Adelaide for identification. According to Hurst, Professor Ralph Tate (Adelaide University), identified it as *Frenela* (letter from Hurst, 20 June 1893), the old name for *Callitris* referred to by Stirling (1900).

Hurst suggested that he collaborate with Stirling in describing the *Diprotodon* remains, took a number of photographs of the operations (Figs 10, 11) and invited Stirling to see the site for himself. Occasional rain showers impeded work but by 25 May when the Government Geologist, H. Y. L. Brown, visited the site, 'three nearly complete skeletons of the diprotodon... [had] been unearthed (Fig. 12), together with over 2000 separate bones of the same animal belonging to over seventy individuals' (*South Australian Register* 23 May, 1893, p. 5). Stirling conveyed this information to

FIGURE 10. Excavating. The posted sign registers the area as a mining 'claim', but the details are illegible. The men are not identified but could include Meldrum. Photo: attrib. H. Hurst. SA Museum Heritage Collection.

the scientific world in a letter published in *The Times* (28 April 1893).

Brown's report (*South Australian Register*, 1 July 1893, p. 6; 1894) generally supported Hurst's claims of the fossil deposit. He noted that articulated footbones, encased in limy concretions that preserved apparent impressions of the sole of the foot, had been found. He further noted that bones of a giant wombat, kangaroos and a gigantic bird occurred in the deposit and he concluded by recommending 'that the whole area of the lake be reserved' for future scientific exploration, 'to prevent the indiscriminate digging up and removal of portions of the specimens.' This sentiment was heartily endorsed by the *South Australian Register* (31 July 1893, p. 6).

When heavy rain came in July, Hurst and Meldrum returned to Adelaide with some of the many bones they had excavated, leaving the rest of the party to continue work. Hurst's verbal report to the Museum Committee members enthused them enough to appropriate another £100 to cover his expenses. In addition two drays were to be despatched from Hawker to bring all the remaining bones from Lake Callabonna at an estimated cost of a further £100. Hurst was to return to the lake forthwith to supervise this packing and dispatch, and await further instructions.

While in Adelaide, Hurst completed (29 July 1893) a preliminary report to the Museum Committee on his journey, excavations and geological observations. This formed the basis for Stirling's subsequent articles (Stirling 1900). Hurst also received a letter from his brother George, still at Lake Callabonna, reporting excitedly:

> As soon as I had dug under the pelvis and into the exact spot where the pouch would be, I came on a dear little diprotodon humerus about six inches long. It is evident the large animal is a female and had a piccaninny diprotodon in her pouch when she died... The claim is very wet and the bones are very difficult to remove but you can depend I will get them all as I think this is the most wonderful discovery ever made in the world. (George Hurst July 1893, *fide* Tedford 1973).

This discovery exemplifies a problem that was beginning to emerge, for while some of these neonate bones have survived, they were, either at

FIGURE 11. Detail of the specimen in Fig. 10. Photo: attrib. H. Hurst. SA Museum Heritage Collection.

the time of excavation or subsequently in Adelaide, separated from those of the putative mother. Stirling was apparently already having misgivings about the procedures being used by Hurst, who had been concentrating on collecting bones that until then were unrepresented or poorly known in collections, and only rarely keeping associated bones together. Had the bones of mother and baby been kept together, the confusion over whether the two forms at Lake Callabonna were different sexes or different species (e.g. Williams 1982: Appendix IV) might have been resolved before now.

Stirling and his assistant, A. H. C. Zietz (Figs 13, 14), spent considerable time sorting through the bones brought down by Hurst, arranging them anatomically. Many had never been seen in such perfect condition, and those of the feet, tail and pouch (epipubes) had not been seen before (*South Australian Register* 31 July 1893, p. 6). Many had suffered during their journey to Adelaide because of poor packing though, and there was additional disappointment that no complete skeleton had been collected.

Stirling hoped that three or four complete skeletons would be sent down to Adelaide in time to be exhibited at the September meeting of the Australasian Science Association (*South Australian Register* 1 August 1893, p. 5).

Hurst went back to the lake early in August, and was followed on 11 August by Stirling, Zietz and Thomas Cornock, the Museum's taxidermist and articulator.

1893, Phase 2

After inspection of the camp and excavation site, Stirling 'was very seriously dissatisfied with the way in which the work had been and was being carried on, [and] gave Mr Hurst and his brother a week's notice of the termination of their engagement, on which they with his consent, left at once.' The other men stayed on. It rained during Stirling's stay and he was unable to carry out the exploration he had hoped to do. After reorganising the party, he put Zietz in charge, confident of the work being done satisfactorily, and left for Adelaide on 21 August (Minutes, special committee meeting 31 August 1893).

Thomas Cornock, who had accompanied

FIGURE 12. Partially excavated *Diprotodon* skeleton. This specimen is lying on its belly, head to the right. Photo: attrib. H. Hurst. SA Museum Heritage Collection.

Stirling and Governor Kintore to Darwin (Palmerston) in 1891, made a number of pencil sketches of specimens and the excavations, which have only recently been rediscovered.

Following Hurst's departure and Zietz's assumption of control of the excavations, there seems to have been little news from the field until Zietz's return and his interview by a reporter from the *Adelaide Observer* (9 December, 1893, p. 33). Hurst had filled twenty-eight wooden cases with bones. Zietz added nearly sixty more. There was one complete skeleton of *Diprotodon*, in good condition, another not so good, and a third of possibly another, smaller species. Amongst other things, they had collected one skull of the giant bird and fragments of another one, a skeleton of the giant wombat and two skeletons of extinct kangaroos, as well as a second juvenile *Diprotodon* (Fig. 15).

Weather and working conditions deteriorated as the year wore on. The drought worsened, as did the rabbit plague. Constant dust storms caused 'sandy blight' eye problems, and the dying rabbits and bad water contributed to gastric illness. Finally heavy rains in November made excavation impossible and the party returned to Adelaide amid great interest from the public and praise from Stirling.

The expedition had originally been financed by the Museum – £250 being scraped from their meagre budget for three months work. This soon ran out and the operation was saved by a generous gift of £500 from Sir Thomas Elder. The Museum was also indebted to the Surveyor General, Mr G. W. Goyder and Mr Peter Waite for services such as supplying camels. Mr Frederick Ragless assisted in various practical ways. Ragless and Meldrum both applied for the reward for the discovery of the *Diprotodon* skeletons. The Museum Board rejected Meldrum's claim in favour of Ragless, but because of the huge financial costs engendered by the expeditions, they were unable to pay the reward.

The specimens

Despite the various problems encountered by the 1893 expeditions, a large number of bones were collected. By far the most numerous were the

FIGURE 13. Dr Edward C. Stirling. Photo: SAM Photo Library.

FIGURE 14. A. H. C. Zietz. Photo: SAM Photo Library.

remains of *Diprotodon* – some eighty specimens were investigated and at least partially collected. Also collected were partial skeletons of several giant birds (*Genyornis*), two giant wombats (*Phascolonus*) and some kangaroos (*Sthenurus* and *Macropus*), as well as the fragmented impressions of *Diprotodon* foot pads, and a mass of comminuted twigs found in the gut region of a *Diprotodon* (Stirling & Zietz 1899).

Reading through Hurst's letters, it is apparent that the list should be larger than this. For instance, he mentions (20 June 1893) several skeletons of a new wombat just found by his brother, that may have 'exceeded a bullock in size', and 'a minute mammal which must prove new to science. The tibia of the latter measures about 2½ inches [6.3 cm] in length'. Although Hurst intended bringing the latter with him to Adelaide, Stirling apparently never saw it and its whereabouts (and identity) is unknown.

Creation of the fossil reserve

The South Australian Government Geologist H. Y. L. Brown visited Lake Callabonna in June 1893. At the end of his report (1894) he recommended that the lake bed be proclaimed a Fossil Reserve 'to prevent the indiscriminate digging up and removal of portions of the specimens' (the suggestion came at a time when an Adelaide syndicate was being floated to do just that).

Brown's far-sighted suggestion was duly followed, and on 5 December 1901 the Lake Callabonna Fossil Reserve was gazetted. It is believed to be the first fossil locality in Australia, and one of the first in the world, to be so declared.

Aftermath

Following his return to Adelaide with the bulk of the fossils found at Lake Callabonna, Zietz immediately plunged into the task of sorting and repairing bones, and compiling a composite set from which to cast a complete skeleton (Stirling 1907). This took many years. The problem was that the bone was impregnated with salts, mainly sodium sulphate, which soaked up moisture during winter and made cleaning and restoration, with the facilities, methods and materials then

FIGURE 15. Associated bones of the juvenile *Diprotodon* found by Zietz's party, August 1893. SAM P10563 Photo: N. Pledge.

available, very difficult (Hale 1956). Meanwhile, he assisted Stirling in describing the giant bird *Genyornis*, and the feet of *Diprotodon* (Stirling & Zietz 1896, 1899a,b). Casting of the bones was done by Robert Limb, father of the entertainer of the same name. A restoration painting of *Diprotodon* in life was done by C. H. Angas (Stirling 1907).

For his part, Stirling decided in 1894 that the lake should be called Lake Callabonna (Board Minutes, 2 February 1894) after Ragless' sheep run that bordered it on the east. It had never formally been named – its common name, Lake Mulligan, was a corruption of 'Mullachon', the name given it in 1860 by Robert Stukey. This was the Aboriginal name for the mound springs on the western side that still are known as Mulligan Springs.

Stirling's study of the fossil remains resulted in several short articles (1893a,b, 1894a,b, 1896a,b, 1900, 1907), and a series of six monographs published in the specially created *Memoirs of the Royal Society of South Australia* between 1899 and 1913.

While Zietz was working on the skeleton of *Diprotodon*, Stirling travelled overseas, visiting museums. Several were interested in obtaining a cast or duplicate specimens of bones of *Diprotodon*, and in this way he obtained by exchange the dinosaur *Diplodocus* leg bones on display on Level 1 of the South Australian Museum. Seven casts of the *Diprotodon* skeleton were eventually distributed.

Preparation of the *Diprotodon* cast was completed in 1906 and unveiled to the public in 1907, together with numerous other specimens.

Conclusions

After 1893, Lake Callabonna lay almost forgotten and undisturbed by scientists for sixty years. The only known visits were by Robert Bedford, of the privately-owned Kyancutta Museum, in 1928 (Cooper 1987) and H.O. Fletcher (1948) from the Australian Museum. It is not known what Bedford collected, but Fletcher found nothing, apparently having gone to a different part of the lake, away from the 1893 site.

In 1953 the Board of the South Australian Museum, at the urging of new member C. W. Bonython, suggested to University of California researcher Professor R. A. Stirton, visiting Australia in search of Tertiary mammals, that reinvestigation of Lake Callabonna would at least bring some positive results for his expedition.

Stirton and Fulbright student R. H. Tedford, together with Museum and University of Adelaide personnel (Stirton 1954) spent three weeks excavating near the site of the 1893 camp which they were able to relocate. Several specimens of *Diprotodon* were collected and taken back to the University of California Museum of Paleontology at Berkeley to be prepared and ultimately studied.

Tedford became fascinated by the locality and in 1970 led a joint expedition with the Smithsonian Institution and South Australian Museum, with excellent results (Tedford 1973). Although *Diprotodon* was the first objective, more important specimens were of *Genyornis* (e.g. Rich 1979), *Phascolonus*, *Protemnodon* and *Sthenurus* (Wells and Tedford in prep.). In 1983 T. Rich and P. V. Rich, with logistic support from the Australian Army, returned to search (fruitlessly) for more *Genyornis* material.

Stirton's 1953 trip could be said to be the beginning of modern mammalian palaeontology in Australia, since it stirred academic and public interest and spawned a growing number of Australian and American students with an interest in the Tertiary and Quaternary of this continent.

We must not, however, forget the thoughtful and interested pastoralists such as Frederick Ragless and enthusiasts like Henry Hurst, and explorers such as Thomas Mitchell who initially brought these fascinating fossils to scientific and public notice.

Acknowledgments

I am indebted to Ms J. M. Scrymgour and her long-time interest in this story for accumulating much of the information and photographs used herein. I thank also Mr E. S. Booth, grandson of Sir Edward Stirling, and Mr Leigh Ragless, grandson of Frederick Ragless, for their interest in providing family photos or records for my use in the exhibition 'Fossils of the Lake' (South Australian Museum, 19 April – 22 August 1993) and subsequently in this article. Ms Jenni Thurmer supplied original glass plate negatives from the South Australian Museum's Heritage Collection. Mr Philip Jones provided assistance with archival research. The manuscript was typed by Ms Debbie Churches.

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SUCCESSION OF PLIOCENE THROUGH MEDIAL PLEISTOCENE MAMMAL FAUNAS OF SOUTHEASTERN AUSTRALIA

RICHARD H. TEDFORD

TEDFORD, R. H. 1994. Succession of Pliocene through Medial Pleistocence mammal faunas of Southeastern Australia. *Rec. S. Aust. Mus.* **27**(2): 79–93.

Southeastern Australia contains the most completely documented Pliocene–Pleistocene faunal succession known on the continent. Magnetostratigraphic, geochronologic and palaeontologic data from the Murray and coastal Victorian basins provide a chronology for local faunas covering early Pliocene through medial Pleistocene time. Changes in the composition of these assemblages appear to be congruent with the physical and palaeobotanical history of southeastern Australia.

The early Pliocene marine transgression in the Murray and coastal basins was accompanied by the spread of rainforest containing diverse arboreal mammals and genera now restricted to the tropics. At the generic level early Pliocene assemblages resemble later faunas and include the earliest appearance of some living and Pleistocene genera along with genera known only from the early Pliocene. Marine regression in the medial Pliocene restored more continental climates to southeastern Australia but the presence of a large lake in the Murray Basin sustained wet sclerophyll vegetation. Living genera whose species now occupy inland environments began to appear there.

At the close of the Pliocene and beginning of the Pleistocene, forms close to living species appear as do species of extinct genera that became common elements in medial and late Pleistocene faunas. Wet sclerophyll vegetation was restricted to the highlands and drier shrubland associations developed in the lowlands as the temperate latitudes of Australia responded to global climatic cooling. By the time more rapid cycling of world climate appears in the medial Pleistocene, the southeastern Australian fauna included most of the associations of taxa that characterized the later part of the Quaternary.

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Manuscript received 19 April 1993

Data reviewed by Woodburne *et al.* (1985) on the succession of mammal faunas in the Murray and adjacent Otway and Gippsland basins of southeastern Australia suggested their singular potential in defining a Pliocene and Pleistocene biostratigraphy for that part of the Australian continent. The locations of most of these faunas are shown in Figure 1. Subsequent study of these assemblages, and further calibration of their succession using paleomagnetic methods (An *et al.* 1986; MacFadden *et al.* 1987; Whitelaw 1989, 1991, 1993) has made it possible to look in more detail at the temporal ranges of taxa and to correlate faunal change with physical and biotic events deduced from other data.

The purpose of this contribution is to examine the chronologic ranges of taxa, principally at the generic level, and then to consider the possible ecological factors that might have guided the succession based on genera whose living species have known habitat preferences. Such extrapolations must be tempered by evidence of shifting habitat for some forms. The pygmy possum *Burramys* is a case in point in which the Pliocene species were associated with lowland rainforest yet its living species is an inhabitant of temperate alpine environments (Flannery *et al.* 1992). It is also important to remember that knowledge of the succession of local faunas and their contained taxa is limited by the geological record of southeastern Australia. Therefore the observed stratigraphic ranges in that area represent only parts of the total ranges of the taxa. Further perspective on the temporal ranges of some Pliocene taxa can be made by comparison with the Lake Eyre Basin and northern Queensland where similarly calibrated faunas are known.

As Whitelaw (1991) pointed out, the magnetostratigraphies relating to individual local faunas cannot in themselves be correlated with the Geomagnetic Polarity Time Scale without evidence from other geochronological disciplines. His work on the faunas of southeastern Australia emphasized those assemblages from deposits

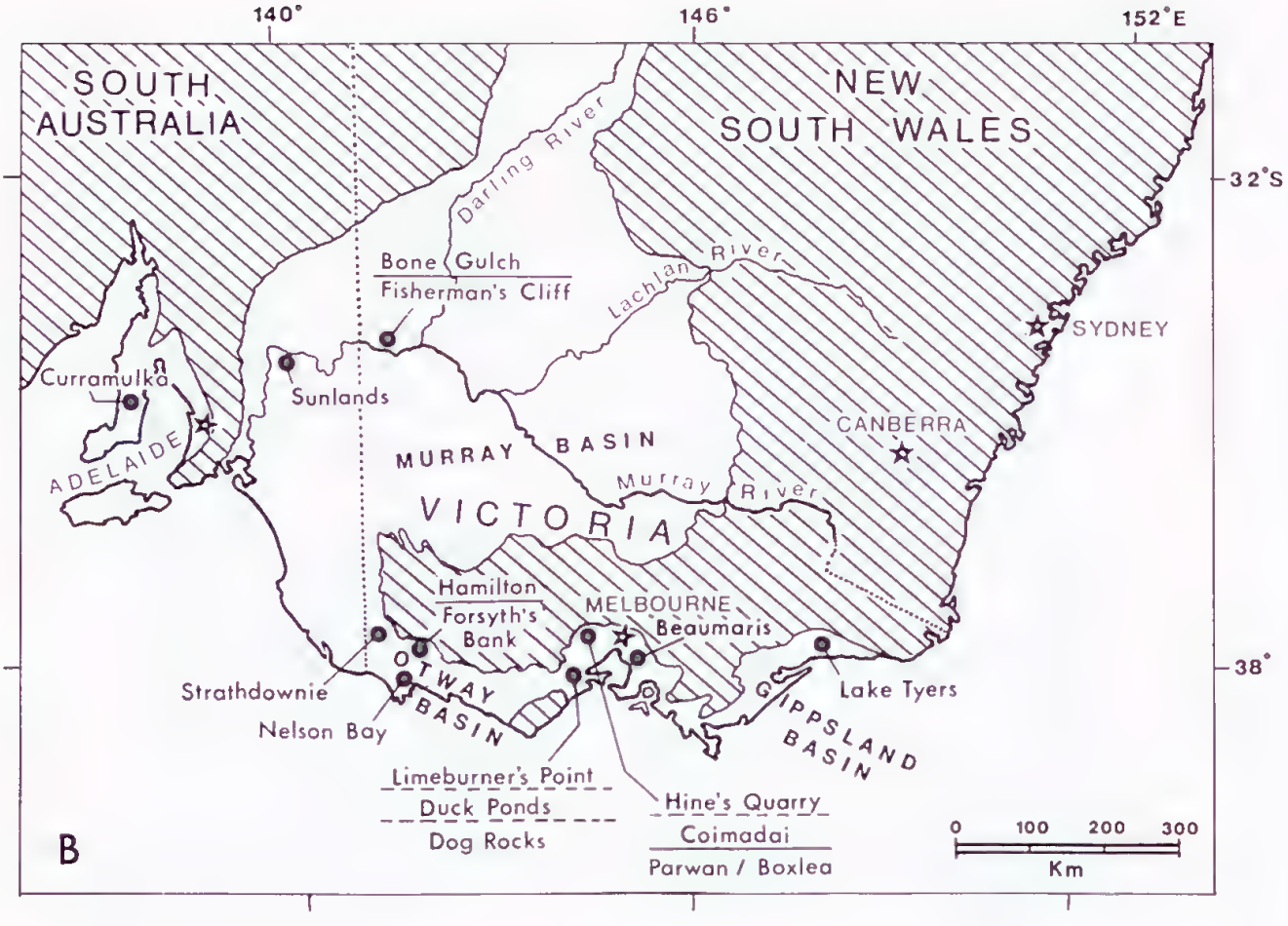

FIGURE 1. Map of south-eastern Australia showing location of sites from which the local faunas mentioned in the text were obtained. Basin margins marked approximately by the 500 ft. contour, highlands above that indicated by shading. The local faunas are listed vertically in ascending stratigraphic order separated by solid lines where in direct superposition and dashed lines where not.

interbedded with volcanic rocks that have been dated using radioisotopic methods. In the case of the Nelson Bay Local Fauna (MacFadden *et al.* 1987; Whitelaw 1991) the presence in the deposits of age-diagnostic planktonic foraminifera provided additional calibration. The Murray Basin sites lie within a longer magnetostratigraphic section that An *et al.* (1986), and Whitelaw (1991) correlate as lying within the Gauss through early Matuyama chrons using the pattern of polarity reversals. In any case, the chronological data constrain the fossil assemblages only to spans of time; shorter where the data are best, and longer where more loosely defined. The correlation chart (Fig. 2) shows these estimated ranges, and the range chart (Fig. 3) uses these estimates of maximum and minimum temporal range for taxa. In addition the total known range is indicated both within and outside southeastern Australia.

This paper follows Cande and Kent (1992) in the calibration of epoch and informally designated subepoch boundaries: Miocene–Pliocene boundary, 5.3 Ma; early Pliocene–medial Pliocene boundary is the Gilbert–Gauss boundary, 3.55 Ma; medial Pliocene–late Pliocene boundary is the Gauss–Matuyama boundary, 2.60 Ma; Pliocene–Pleistocene boundary, is at the end of the Olduvai Subchron, Matuyama Chron 1.76 Ma; early Pleistocene–medial Pleistocene boundary is informally set at the end of the Matuyama Chron, 0.78 Ma; medial Pleistocene–late Pleistocene boundary is informally set at 0.40 Ma; late Pleistocene–Holocene boundary is at 0.01 Ma (Ma: million years on the geological time scale;

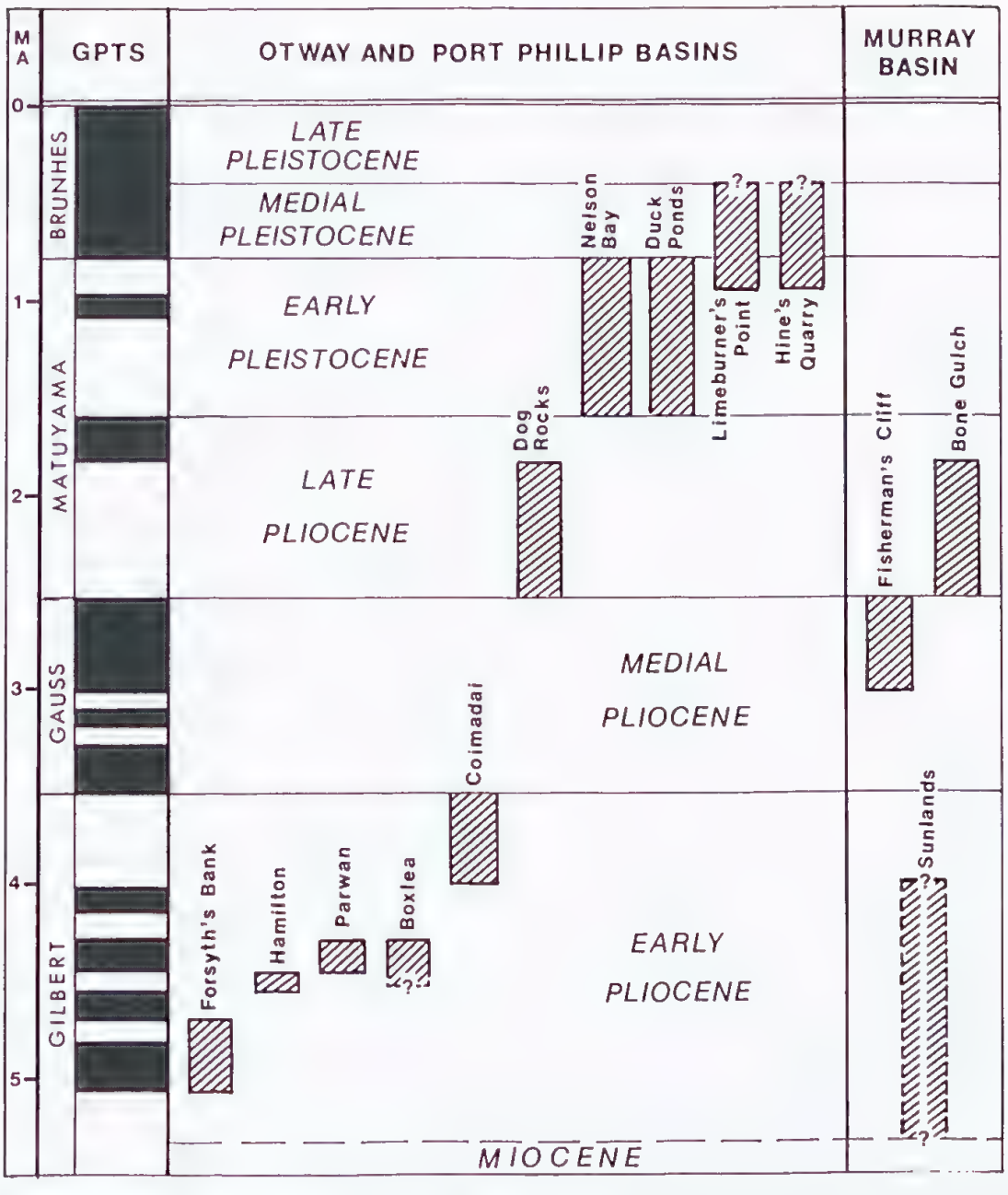

FIGURE 2. Approximate limits in time for the local faunas discussed in the text as deduced from palaeomagnetic data and correlations to the Geomagnetic Polarity Time Scale (GPTS). Although each local fauna is essentially a point in geologic time this cannot be more closely constrained than the limits shown (Whitelaw 1991). The Sunlands Local Fauna from the Murray Basin has no supporting paleomagnetic data, but is given a chronologic position correlative with assemblages in the Otway Basin that belong to the early phase of the Pliocene transgression recorded in both basins. Calibration of the GPTS follows Cande and Kent (1992).

M.y.: span of time, millions of years long).

Extinct taxa are indicated in the text by a preceding asterisk *.

The faunal record

The geochronological range chart (Fig. 3) plots the time spans for selected genera of marsupials and one family of rodents. These are arranged to show the succession of forms, but the following analysis of this record will discuss each family in systematic order. The best available faunal lists are given by Rich *et al.* (1991) and the sources for these lists are given there. Since 1991, additional faunas, pertinent to this review, have appeared including those in Flannery *et al.* (1992); Pledge (1992); Tedford and Wells (1992) and Turnbull *et al.* (1992 and 1993). Whitelaw (1991, 1992) gives lists for the Pleistocene faunas and references. An asterisk indicates extinct taxa. Two sites deserve further discussion:

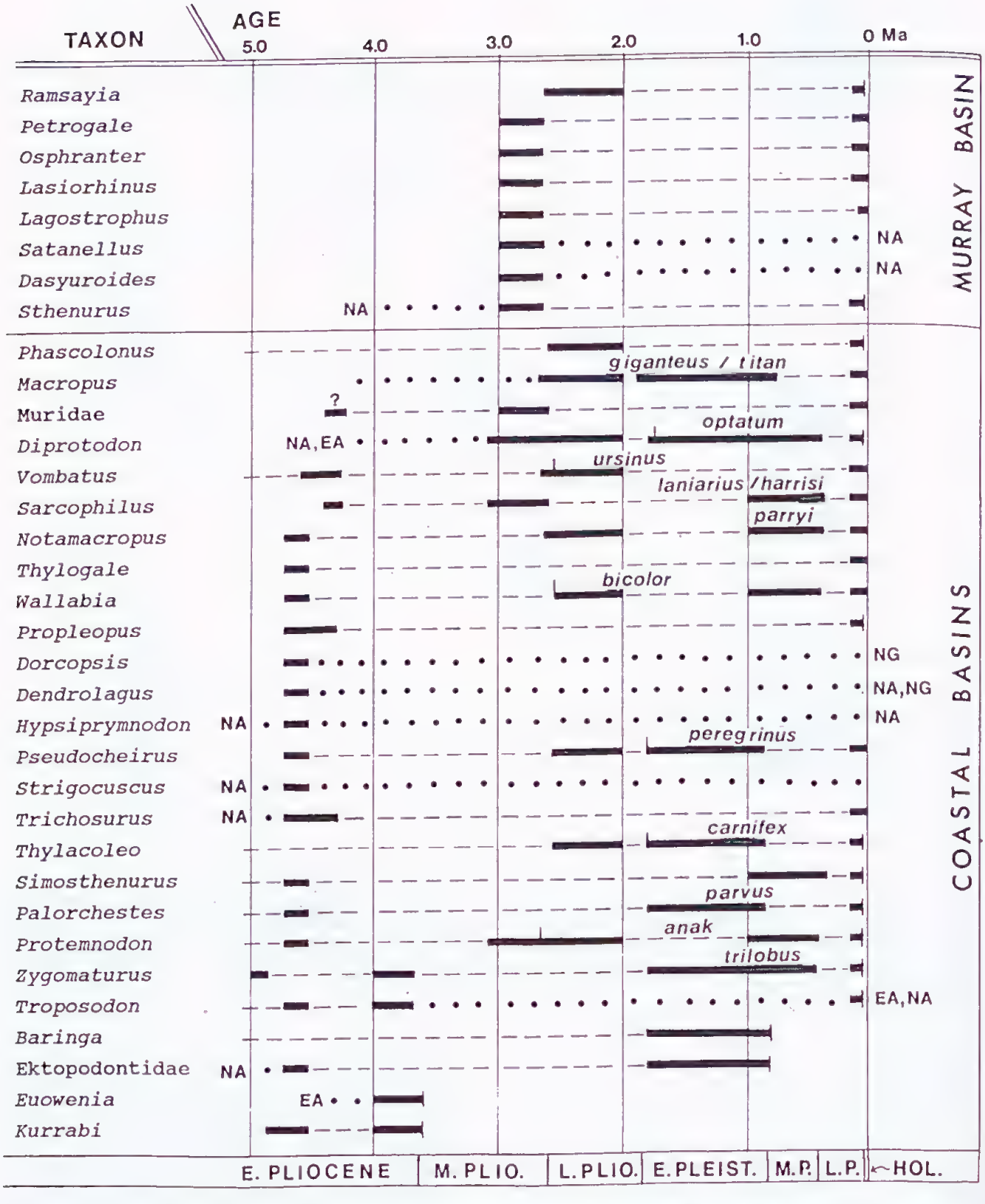

FIGURE 3. Geochronologic ranges for selected taxa discussed in the text following the data of Fig. 2. Taxa divided into coastal Victoria and Murray basins with regard to first occurrences. Dashed connections of occurrences refer to southeastern Australia (including South Australia), dotted connections indicate earlier or later occurrences in other parts of the continent [EA, eastern Australia; NA, northern and central Australia, NG, New Guinea] for taxa whose ranges begin outside southeastern Australia and others that become restricted with time.

The newly described Curramulka Local Fauna (Pledge 1992) from Yorke Penninsula, South Australia (Fig. 1) appears on stage-in-evolution criteria of its marsupials to predate the assemblages discussed here. The fact that it contains several genera that are components of Pliocene and Pleistocene faunas of southeastern Australia suggests that the Curramulka Local Fauna is at least of late Miocene age. The local fauna contains a number of arboreal forms but lacks those having species in present-day rainforest. It provides valuable perspective in our assessment of the history of certain genera and relevant information from this fauna will be included in the following summaries and discussion.

The Beaumaris marsupial assemblage from the Port Phillip Basin (Fig. 1) consists of five specimens collected over the past one hundred years from outcrops of the Black Rock Sand Member of the Sandringham Formation at Beaumaris. Producing strata include the nodule bed that lies directly on a surface cut on the medial Miocene Fyansford Formation, and the overlying calcareous and ferruginous sands. None of the material has precise provenance, but differences in permineralization suggest different geochemical environments that may be indicative of stratigraphic position. In an effort to test the provenance of the material Gill (1957a) determined the flourine-phosphate ratios of the bony parts of three of the specimens and found a spread of values separated by only 0.5–0.6%. Similar determinations from the bony parts of shark teeth, some known to be from the "nodule bed," produced a similar range of values. Gill concluded that the nodule bed was the probable source of the marsupial bones. Despite this there is still the possibility that the Beaumaris marsupial assemblage is a composite of older remanié and younger autochthonous material. Carter (1978) examined foraminifera from the "nodule bed" and found remanié material, the youngest of which was of medial Miocene age. Miocene squalodont whale teeth and the nautiloid **Aturia* from Beaumaris also suggest that they are remanié lying within the "nodule bed" on the surface of disconformity.

The heavily permineralized **Kolopsis* sp. right ramus (Nat. Mus. Vict. P15911) described by Stirton (1957) and Woodburne (1969 as *Zygomaturus gilli*) is water-rolled and bored from exposure on the marine platform developed on the Fyansford Formation. A left ramus of **Kolopsis* sp. (Nat. Mus. Vict. P16279), purchased by the Museum of Victoria from Albin Bishop in 1910 and thought to be from Chinchilla, Queensland (Stirton 1957: 128), may actually be from Beaumaris because it is encrusted with calcareous tubes of spirorbid worms (T. Rich, pers. com. 1979) and preserved in a manner similar to NMV P15911. These specimens may be remanié. Murray *et al.* (1993) compare **Kolopsis* sp. with **K. yperus*, a taxon from Miocene deposits disconformably overlying those that contain the Alcoota Local Fauna in Northern Territory. They contend that **Kolopsis* sp. lies morphologically between **K. torus* (Alcoota) and **K. yperus*, thus supporting a Miocene age for **Kolopsis* sp. on stage-in-evolution criteria.

The **Zygomaturus gilli* holotype P3/ and referred maxilla (Stirton 1957) and more recently discovered lower molar (Rich 1976), are more pristine in preservation and may actually be derived from the immediately overlying Black Rock Sand. In their evaluation of zygomaturine phylogeny, Murray *et al.* (1993), place **Z. gilli* above **K. yperus* at the base of the genus **Zygomaturus* further emphasizing its phylogenetic separation from **Kolopsis* sp. Rich *et al.* (1991) add '*Palorchestes* sp.' to the Beaumaris faunal list, but this reference seems to come from older identifications of the **Z. gilli* holotype cited in the synonomy provided by Stirton (1957).

The marine invertebrate fauna of the transgressive Black Rock Sand was used by Singleton (1941) to typify his Cheltenhamian Stage. Despite the similarity of its molluscs to those of the succeeding Kalimnan stage, he assigned the Cheltenhamian to the Upper Miocene, largely on the basis of the occurrence of teeth of the cetacean *Parasqualodon* and the nautiloid *Aturia* not known to survive the Miocene, but very likely remanié at Beaumaris as stated above. Elsewhere in the Port Phillip and Gippsland basins a surface of disconformity of similar character, developed on Miocene marine strata, is overlain by marine deposits of Kalimnan age (including the deposits containing the type fauna defining the age at Lake Tyers, Gippsland). In Gippsland the Jemmys Point Formation also rests on the same phosphatic nodule-bearing surface of disconformity (Carter 1978). The evidence thus seems to indicate that molluscan faunas indicative of the Cheltenhamian and Kalimnan stages belong to the same transgressive interval. Furthermore Darragh (1985) showed that molluscan assemblages typical of the Cheltenhamian and Kalimnan are superposed

within the Jemmys Point Formation outcrops at Bunga Creek near Lakes Entrance, Victoria. Ludbrook (1973: 253–255) gave an historical review of this problem which has become entwined with efforts to recognize the Miocene–Pliocene boundary.

For the purposes of this review, a Pliocene age is assigned to the initiation of the Kalimnan transgression. The earliest molluscan faunas associated with this transgression are of Cheltenhamian composition. They are associated with terrestrial vertebrates only at Beaumaris. If **Zygomaturus gilli* is autochthonous in the Black Rock Sand, it represents the oldest Pliocene taxon in southeastern Australia. The marine Grange Burn Coquina, with an occurrence of the kangaroo **Kurrabi* sp. (Forsyth's Bank Local Fauna), contains a molluscan fauna of Kalimnan type (Ludbook 1973) representing a later phase of the Pliocene transgression. This unit is not well constrained magnetically (Fig. 2 and Whitelaw 1991).

Dasyuridae

Most species are small so that the record of this group is biased toward those sites that have been screen-washed. Some living genera have Pliocene records: *Sminthopsis* sp. cf. *S. macroura* (Fisherman's Cliff), *Antechinus* sp. (Hamilton, Fisherman's Cliff, Dog Rocks), *Satanellus hallucatus* (Fisherman's Cliff), *Dasyurus* sp. (Fisherman's Cliff, Dog Rocks), and *Dasyuroides *achilpata* (Fisherman's Cliff). The living *Sminthopsis crassicaudata* has a medial Pleistocene record at Hine's Quarry. The record of the largest dasyurid, *Sarcophilus*, begins in the early Pliocene with an unallocated species (Parwan) followed by a relatively primitive species, *S. *moornaensis* (Fisherman's Cliff), in the late Pliocene. Representatives of the living species, or its close ally *S. *laniarius* (a subspecies of *S. harrisii* to some, Werdelin 1987), occur in early Pleistocene deposits (Limeburner's Point). **Glaucodon ballaratensis*, which appears to be a member of the Tasmanian Devil clade, occurs only in deposits at Smeaton, Victoria, that have a Late Pliocene maximum age (Turnbull *et al.* 1993). This genus is thus overlapped in range by its sister taxon *Sarcophilus*.

Thylacinidae

Curiously, there is no Pliocene record of thylacines in southeastern Australia but the genus is recorded in the Miocene Curramulka Local Fauna of South Australia (Pledge 1992). There is a long record of the genus extending from the Miocene into the late Pleistocene in northern Australia and New Guinea. The Nelson Bay species, close to the modern *Thylacinus cynocephalus*, may be the earliest known occurrence of this recently extinct taxon.

Peramelidae

This family is also poorly represented in the record, very likely because all members are small animals. Unidentified peramelids occur at Hamilton and Fisherman's Cliff, but at Dog Rocks, at the close of the Pliocene, *Perameles* sp. and *Isoodon* sp. are both recorded.

Thylacomyidae

There are no records of bilbies in southeastern Australia until the late Pleistocene when *Macrotis* is present in the Murray Basin.

Thylacoleonidae

Fragments of the dentition and skeleton of **Thylacoleo* sp. were recovered with the Curramulka Local Fauna (Pledge 1992) of South Australia. The nearby Town Cave produced a single P3/, the type of **T. hilli* Pledge 1977, which is the most primitive member of the genus and could be a contemporary of the Curramulka assemblage. Unfortunately the fragments from these sites do not include comparable elements, nevertheless the records do indicate the presence of the genus prior to its Pliocene appearance in southeastern Australia. This record begins with **Thylacoleo* sp. at the late Pliocene Bone Gulch site in the Murray Basin. Material that can be identified with the widespread Pleistocene species, **T. carnifex*, occurs in the early Pleistocene Duck Ponds Local Fauna.

Vombatidae

Pledge (1992) records *Vombatus*, *Phascolonus* and '*Phascolomys*' sp., cf. '*P.*' *medius* from the later Miocene Curramulka Local Fauna of coastal South Australia. Early Pliocene representatives of *Vombatus* are known at Boxlea and Coimadai, including *V. *parvus* as well as a larger form, *V.* sp. *Vombatus ursinus* is also present at Dog Rocks by the late Pliocene. *Lasiorhinus* is present by medial Pliocene time in the Murray Basin (Fisherman's Cliff) and a large species, comparable to '*Phascolomys*' **medius*, is present in the Port Phillip Basin (Limeburner's Point) by the medial Pleistocene. Giant wombats also occur in the late Pliocene, **Phascolonus* sp. (Dog

Rocks) and **Ramsayia* sp. cf. *R. magna* (Bone Gulch).

Diprotodontidae

Remains of these large animals are present at nearly all sites providing a more continuous record than for other groups except the Macropodidae. There is considerable late Cainozoic diversity within the family, perhaps denoting a span of maximum cladogenesis within the group. The diprotodontid record in southeastern Australia in the Pliocene includes the diprotodontines **Euowenia* sp. (Coimadai), a new genus at Hamilton, and, perhaps, **Diprotodon* itself at Fisherman's Cliff and Dog Rocks. The earliest record of **Zygomaturus*, *Z. gilli*, occurs in the Black Rock Sand at Beaumaris in the Port Phillip Basin. This is here regarded as earliest Pliocene as discussed above. Other Pliocene occurrences of **Zygomaturus* sp. are known at Coimadai and Dog Rocks. **Zygomaturus trilobus* and **Diprotodon* sp. are present at Nelson Bay in the early Pleistocene. By medial Pleistocene time **Diprotodon optatum* is present at Duck Ponds (as '*D. longiceps*'), Limeburner's Point and Hine's Quarry. The continent-wide diprotodontid record shows a reduction in diversity at the close of the Pliocene with only **Diprotodon optatum* and **Zygomaturus trilobus* extending into the late Pleistocene.

Palorchestidae

A relatively primitive early Pliocene species, of **Palorchestes*, perhaps close to the northern Australian Miocene *P. painei*, occurs at Hamilton. A similar form occurs in the later Miocene Curramulka Local Fauna of South Australia (Pledge 1992). The small **P. parvus* is present in the early Pleistocene (Nelson Bay) and this taxon survives into the late Pleistocene at Strathdownie Cave in western Victoria (Gill 1957b). There is no early record of the giant **P. azael* in southeastern Australia although it occurs there in the late Pleistocene.

Phascolarctidae

Koalas are diverse in Miocene deposits of interior Australia, but the earliest representative of the genus *Phascolarctos* occurs in the later Miocene Curramulka Local Fauna of coastal South Australia (Pledge 1992). A primitive early Pliocene species, *P. *maris*, occurs in the shallow-water marine Loxton Sands in the Murray Basin (Sunlands Local Fauna, Pledge 1987). A species of koala close to the living *Phascolarctos cinereus* is present in the late Pleistocene of southeastern Australia. The genus is not recorded in intervening deposits.

Ektopodontidae

Species of the genus **Darcius* are known only from Hamilton and another genus of this family survived into the early Pleistocene at Nelson Bay (M. Whitelaw, pers. comm. 1993) representing a relictual occurrence of an important Miocene group.

Phalangeridae

Members of this family occur in the early Pliocene: *Trichosurus* sp. at Boxlea, and *T. *hamiltonensis* and *Strigocuscus *notalis* occur together at Hamilton. In the late Pliocene, *Phalanger* sp. is recorded at Dog Rocks.

Petauridae

Forms close to living small gliders are known from Hamilton largely because of the intensive screen-washing there. A *Petaurus* sp., close to *P. norfolcensis*, also occurs in the late Miocene Curramulka Local Fauna of South Australia (Pledge 1992). Pseudocheirines are somewhat larger forms and thus have a wider record before the late Pleistocene in southeastern Australia. The early Pliocene Hamilton Local Fauna contains two extinct *Pseudocheirus* species, one that appears to be related to the living *Petauroides* (*Pseudocheirus *stirtoni*) and the other to members of the living subgenus *Pseudocheirus* (*P. *marshalli*). Two unidentified species of *Pseudocheirus* are present in the late Pliocene (Dog Rocks) and a species close to the living *P. peregrinus* is present in the early Pleistocene at Nelson Bay. The latter site also contains a new genus of giant pseudocheirine. Additional early Pliocene diversity in the ringtail group is also indicated by **Pseudokoala erlita*, known only from Hamilton.

Burramyidae

In the well-sampled Hamilton site a species of *Burramys* (*B. *triradiatus*) occurs in a rainforest setting near sea level. This genus is not further represented in southeastern Australia until the late Pleistocene when the living *B. parvus* appears in superficial deposits in caves in the Buchan district, Victoria, at about 600 m elevation. In the Holocene it retreated to above 1300 m to be associated with alpine environments.

Potoroidae

This family has a long Neogene record in central and northern Australia, the living genera appear in the Miocene in that region. The recently described Curramulka Local Fauna (Pledge 1992) of later Miocene age also contains an early record of *Potorous*. Hypsiprymnodontines, both *Hypsiprymnodon* sp. and the larger **Propleopus* sp., occur in the early Pliocene (Hamilton), and the latter also at Boxlea, perhaps the earliest record of the genus. **Milliyowi bunganditj*, a newly recognized potoroid of uncertain affinities, occurs only at Hamilton indicating some diversity within the group in the coastal early Pliocene. *Bettongia* sp. is known in the medial Pliocene in the Murray Basin (Fisherman's Cliff). By the close of the Pliocene *Potorous* sp. and a form near *Bettongia* are present in the Port Phillip Basin at Dog Rocks. These potoroid genera are common in the late Pleistocene of southeastern Australia.

Macropodidae

By Pliocene time most of the living genera of Macropodinae had appeared in the Australian record, as had most of those representing the diverse Sthenurinae. There are no living macropodine genera in Miocene sites. The record in southeastern Australia documents the loss of several early genera as well as early species of surviving genera during the later Pliocene. Genera whose living species have northern Australian and New Guinea distributions also fail to persist in the southeast beyond the medial Pliocene.

Sthenurine kangaroos such as **Troposodon* and **Simosthenurus* have later Miocene records at Curramulka in South Australia and early Pliocene records at Hamilton. **Troposodon* did not persist in southeastern Australia, but survived into the late Pleistocene in northern and eastern Australia. **Sthenurus* appears by the medial Pliocene (Fisherman's Cliff), and continues into the late Pliocene (Bone Gulch) and the late Pleistocene in the Murray Basin. Species of *Sthenurus* are present in the coastal regions in the late Pleistocene although they are not as diverse as in the inland. **Simosthenurus* species, such as **S. mccoyi*, that are close to later Pleistocene forms, are present in the medial Pleistocene of the Otway Basin. Species of this genus are most numerous in the coastal districts of southeastern Australia during the late Pleistocene.

Macropodines of the early Pliocene of southeastern Australia include extinct genera that did not persist into the later Pliocene; extinct genera whose early species did not persist into the Pleistocene; living genera whose ranges contracted so that they were no longer present in the southeastern Australian Pleistocene, and living genera that continue to exist in southeastern Australia. Examples of the first are species of **Kurrabi* (**K. pelchenorum*) at Hamilton and **Kurrabi* sp. at Coimadai and Forsyth's Bank (Flannery *et al.* 1992). The second case is exemplified by early **Protemnodon* species such as the **P. chinchillaensis* that occurs in Kalimnan strata at Lake Tyers (originally identified as **P. otibandus*, Plane 1972, reidentified by Rich *et al.* 1991) and **P.* cf. *otibandus* at Hamilton. The last recorded occurrence in southeastern Australia of such early species of **Protemnodon*, is **P. devisi* from the Fisherman's Cliff Local Fauna of late Pliocene age in the Murray Basin.

Dorcopsis (*D. **wintercookorum*) and cf. *Dendrolagus* occur in the early Pliocene of the Otway Basin (Hamilton). *Dorcopsis* is also present in the western Murray Basin (Sunlands) in the early Pliocene. These living genera do not have later records in southeastern Australia. On the other hand species of *Thylogale* (*T. **ignis*), perhaps *Wallabia* and *Macropus* (*Notamacropus*) are recorded in the early Pliocene of the Otway Basin (Hamilton). In medial Pliocene time *Lagostrophus* sp. cf. *L. fasciatus*, *Petrogale* sp. and *Macropus* (*Osphranter*) sp. are present in the Murray Basin (Fisherman's Cliff).

Species of *Macropus (Macropus)* may be present in the early Pliocene (Coimadai), but a more secure record is present only late in the epoch at Dog Rocks in the Port Phillip Basin where species close to the living grey kangaroos (both *M. giganteus* and *M. fuliginosus*) occur. The occurrence of a skeleton of *Macropus giganteus* beneath basalt in the Great Buninyong Estate Mine, Victoria, implies significant antiquity for this taxon, perhaps predating 2.5 Ma, the age of basalt flows in the vicinity (Rich *et al.* 1991). The Dog Rocks site also produced the earliest record of *Wallabia bicolor* and a wallaby near *M.* (*Notamacropus*) *irma*, presently confined to Western Australia. A large **Protemnodon*, comparable to **P. anak*, succeeds earlier species in the late Pliocene (Dog Rocks).

By the beginning of the Pleistocene *Macropus* (*M.*) **titan* appears with **Protemnodon* sp. cf. *P. anak* at Duck Ponds, the earliest record of coexistence of two of the more common Pleistocene macropodid species. At Nelson's Bay the occurrence of **Baringa nelsonensis* indicates survival into the Pleistocene of a macropodine also known in the late Miocene Curramulka Local Fauna of South Australia.

The small samples available of medial Pleistocene faunas (Limeburner's Point and Hine's Quarry) indicate the continued occurrence of larger *M.* (*Macropus)* and **Protemnodon*, the presence of smaller *Macropus* species, *Wallabia* sp. cf. *W. bicolor* and *Macropus* (*Notamacropus*) sp. cf. *M.* (*N.*) *parryi* at Limeburner's Point and the possible survival of the northern Australian Pliocene **Prionotemnus* sp. at Hine's Quarry. Lack of Murray Basin sites of earlier Pleistocene age prevent establishment of the ranges of *Lagorchestes* and *Onychogalea*, genera that were common there in the late Pleistocene and Holocene.

Muridae

The array of small mammals obtained from the Hamilton site through intensive screen-washing lends credence to the absence of murid rodents there. Likewise the Miocene Curramulka Local Fauna lacks rodents although it has rodent-sized small marsupials. They have been reported from Parwan whose estimated age is 4.0 Ma., but supporting collections cannot be found in the Museum of Victoria. Thus the earliest verfied occurrence in southeastern Australia is the material from the medial Pliocene Fisherman's Cliff Local Fauna in the Murray Basin. At that time the murids had achieved considerable diversity (Crabb 1976) and living genera such as *Pseudomys*, *Leggadina*, *Leporillus* and *Notomys* have been identified there. *Pseudomys* is also present in the late Pliocene (Dog Rocks) of the Port Phillip Basin.

Implications of the faunal record

Despite its obvious imperfections, the Pliocene–Pleistocene faunal sequence in the Murray and coastal basins of Victoria constitutes the most complete record of faunal change for that interval presently known on the continent. Central Australia (Lake Eyre Basin) and northeastern Australia (Charters Towers area) contain important dated early Pliocene assemblages, but large gaps separate these from younger Pleistocene faunas in the same districts. The record from the Murray Basin has a similar gap, but its medial Pliocene record nicely complements the coastal sequence. This is important as faunas on either side of this gap differ significantly through extinction, evolution and zoogeographic changes of their components. The evidence from the Murray and coastal basins not only supports this conclusion, but allows us to chart the changes and provides a rough chronology for them.

Reassembling the faunal records temporally, three responses seem to be in play during a span of faunal change: 1) extinction of pre-existing taxa, 2) survival and, in some cases, evolution of pre-existing taxa, and 3) changes in geographic range of surviving taxa so that they become locally extinct. As the range chart (Fig. 3) indicates, important faunal turn-over occurred during the medial to late Pliocene. In the southeastern Australian early Pliocene a number of living and Pleistocene genera are already present, including *Antechinus*, *Sarcophilus*, *Strigocuscus*, *Vombatus*, **Diprotodon*, *Hypsiprymnodon*, **Propleopus*, *Dendrolagus*, *Dorcopsis*, **Protemnodon*, **Troposodon*, **Simosthenurus*, *Thylogale*, *Wallabia* and *Macropus* (*Notamacropus*). **Euowenia*, **Darcius*, **Troposodon* and **Kurrabi* have records limited to the early Pliocene in southeastern Australia, while *Strigocuscus*, *Hypsiprymnodon*, *Dorcopsis* and *Dendrolagus* are not known in the region after the early Pliocene. However species of these living genera are restricted to northern Australia and New Guinea today, and **Tropososon* continued to be represented in eastern and northern Australian faunas into the late Pleistocene.

During the medial Pliocene in the Murray Basin additional living genera occur, some represented by species that appear limited to the Pliocene: *Sminthopsis*, *Dasyuroides* and *Dasyurus*, *Satanellus*, *Lasiorhinus*, *Bettongia*, *Macropus* (*Osphranter*), *Petrogale* and *Lagostrophus*. *Dasyuroides* and *Satanellus* are not known in younger faunas, but occur in northern Australia today. **Sthenurus* occurs first in the Murray Basin and becomes a member of the coastal assemblage by the late Pleistocene.

In the late Pliocene some living species, or forms close to them, appear in the Port Phillip Basin: *Vombatus ursinus*, *Wallabia* sp. cf. *W. bicolor*, *Macropus* (*Macropus*) sp. cf. *M.* (*M.*) *giganteus*, *M.* (*M.*) sp. cf. *M.* (*M.*) *fuliginosus* and *M.* (*Notamacropus*) sp. cf. *M* (*N.*) *irma*. Some extinct genera must have undergone species level changes during this interval for by the beginning of the Pleistocene **Diprotodon optatum*, **Zygomaturus trilobus*, **Thylacoleo carnifex*, and **Protemnodon anak* appear in coastal Victoria. **Ramsayia magna* also appears in the late Pliocene of the Murray Basin. These taxa, along with *Macropus* (*Macropus*) **titan*, are among the

most widespread components of the Pleistocene faunas of southeastern Australia.

In early to medial Pleistocene time some Tertiary relicts have their last appearances: *Ektopodontidae, **Baringa* and perhaps **Prionotemnus*. Further diversity is evident in living genera [e.g. *Macropus* (*Notamacropus*) sp. cf. *M.* (*N.*) *parryi*] and extinct forms such as "*Phascolomys*" cf. **medius* are present. Extinct genera such as **Simosthenurus* show initial phases of speciation (**S. mccoyi*) heralding their later Pleistocene radiation.

Palaeoecological interpretations from the mammalian fauna

Despite its inadequacies, the faunal evidence from southeastern Australia supports three general ecological conclusions. The first is that early Pliocene sites have genera whose living species are now members of the tropical rainforest assemblage, notably *Hypsiprymnodon*, *Dendrolagus*, *Dorcopsis* and *Strigocuscus* from Hamilton and *Dorcopsis* at Sunlands, suggesting similar environments prevailed in the Otway and western Murray basins at that time. Such taxa do not appear in younger Pliocene sediments of the coastal region, although there is a clear signature of relatively humid later Pliocene environments with *Vombatus*, *Potorous*, *Wallabia*, *Macropus* (*Notamacropus*), *Thylogale* and arboreal phalangerids and petaurids, all taxa that today inhabit wet sclerophyll forest.

Secondly there is an ecological contrast between the inland Murray Basin and coastal Victoria when comparable records are available in the medial to late Pliocene. Arboreal taxa are more commonly recorded on the coast, less frequently inland, judging from comparably collected sites (compare Fisherman's Cliff and Dog Rocks). Certain genera whose living species were widely distributed in the modern arid zone in immediately pre-European times (*Dasyuroides*, *Lasiorhinus*, *Leggadina*, *Leporillus*), or are strongly represented in the arid-zone today (*Macropus* (*Osphranter*), *Petrogale*, *Notomys*, *Pseudomys*), are found in the Murray Basin in the medial to late Pliocene suggesting a climatic gradient similar in orientation to that of today.

A third conclusion is that the Pliocene assemblages of both the coastal and inland sites contain associations of living genera not known today. Flannery *et al.* (1992) point out the association of *Trichosurus* and *Strigocuscus* at Hamilton as an example of taxa whose ranges do not overlap today, and the coexistence of *Hypsiprymnodon*, *Dorcopsis* and *Burramys* is another example from the same assemblage. Likewise, in the medial Pliocene of the Murray Basin (Fisherman's Cliff), *Lagostrophus*, *Dasyuroides*, and *Satanellus* are genera now widely separated zoogeographically. Such coexistence of taxa in communities that lack modern analogues (the "disharmonious associations" of Lundelius 1983) imply unusually patterned environments or subsequent adaptations of species of these genera to habitats occupied by their living representatives. The latter is clearly the case for the species of *Burramys*, as already mentioned.

Dated early Pliocene assemblages are known in central Australia (Tirari Formation local faunas, Lake Eyre Basin, Tedford and Wells 1992) and northeastern Australia (Bluff Downs Local Fauna, Queensland, Archer and Wade 1976). Both contain rodents and on this basis may slightly post-date the Hamilton Local Fauna. They are constrained by local geochronological indicators that suggest an age near 4 Ma for both areas. Except for the presence of a large *Dendrolagus* and the phascolarctid **Koobor* these northern faunas are dominated by terrestrial forms. The Pliocene genera **Euowenia* and **Kurrabi* are shared with southeast Australia and **Diprotodon* also occurs in the Tirari faunas. There are early Pliocene occurrences of living genera such as *Lagorchestes*, *Macropus* (*Osphranter*) and *Macropus* (*Macropus*), and extinct genera **Thylacoleo*, **Phascolonus*, and **Sthenurus* in the northern assemblages, the latter predates its record in southeastern Australia. The association of *Dendrolagus* with *Macropus* species and *Lagorchestes* has no modern equivalent but could indicate a vegetational mosaic, possibly riparian gallery forest and more open associations on river valley interfluves, with the remains of taxa from parts of the mosiac being brought together by fluviatile agencies. The comparison between southeastern and northern Australian Pliocene faunas suggests different zoogeographic patterning, broader mesic environments and less climatic diversity than present today.

Palaeoecological interpretations from geological history and the palaeobotanical record

Comparison of the faunal succession and its palaeoecological interpretation with physical and

other biological events in southeastern Australia indicates sufficient congruence in the timing and nature of change to suggest global controls of the events. Brown and Stephenson's (1991) masterful synthesis of the history of the Murray Basin is heavily drawn upon in the following account.

A hiatus of about 4 M.y. accompanies the late Neogene regression in the Murray and coastal basins during which these basins were emergent for much of the late Miocene. The sea withdrew beyond the present coastline, possibly to the continental edge, and the Murray Basin environment in particular became continental. Martin's (1987) study of the vegetational changes in the Lachlan Valley in the eastern Murray Basin shows that this period of emergence is accompanied by the first appearance of wet sclerophyll forest following a long Palaeogene and early Neogene occurrence of rainforest formations in the basin. The Curramulka Local Fauna of Yorke Penninsula, South Australia belongs to this regression. The cave system from which the fauna was recovered was open to the surface and collecting terrestrial debris during a period of lower water table. Lack of rainforest taxa in the assemblage perhaps reflects the drier environment in the karstic uplands of the peninsula.

The subsequent Pliocene transgression in the Murray Basin was accompanied by deposition of the shallow-marine Bookpurnong Beds followed by the marine Loxton Sand. During this high stand of sea level, rainforest vegetation redeveloped in the eastern part of the Basin. Martin (1937) has shown that although this forest contains *Nothofagus* species, only the temperate species groups are represented and these may have been restricted to the uplands surrounding the basin and to the more protected river valleys. Judged by its mammalian inhabitants, early Pliocene lowland rainforest of southeastern Australia may have resembled present-day rainforest of northeastern Australia. The few terrestrial fossils obtained from the Loxton Sand in the western part of the basin (Sunlands Local Fauna, Pledge 1985, 1987) include a large koala (*Phascolarctos *maris*), *Dorcopsis* sp. and a *zygomaturine diprotodontid. This assemblage may be approximately correlative with the Hamilton and Forsyth's Bank local faunas in the Otway Basin and the Lake Tyers Local Fauna in the Gippsland Basin, all occur in the transgressive phase of sedimentation (the Kalimnan Stage) in their respective basins. These assemblages are the only Pliocene faunas containing rainforest taxa.

When the sea withdrew from the Murray Basin in the early Pliocene, strandline dunes followed (Parilla Sand) and finally fluviatile deposits (Moorna Sand) penetrated interdune regions as regional drainage was re-established. Increasingly continental conditions in the Murray Basin were accompanied by the final demise of the rainforest and myrtaceous sclerophyll vegetation reappeared in the basin (Martin 1987). The Fisherman's Cliff Local Fauna was contemporaneous with this phase of regression and reflects the change to drier environments. Judged by the development of silicified ferruginous soils on the stabilized regression surface (the Karoonda Surface of Firman 1966), the climate included higher, and perhaps less seasonal, rainfall and temperatures higher than present.

In the Otway Basin the regression was accentuated by tectonic and thermal uplift accompanying the onset of the volcanism that built the Newer Volcanic plateau of western Victoria. The Port Phillip Basin forms part of the hinge zone between the Otway and Gippsland Basins. Its geological history resembles the latter, but late Neogene sequences are thinner and Newer Volcanic flows punctuated the section during the Pliocene. In the Port Phillip Basin the early Pliocene regression was accompanied by dissection of the Kalimnan transgressive sands (Moorabool Viaduct Sand). Backfilling of the erosion surface by thin marine deposits containing faunas attributed to the Werrikooian Stage (Carter 1985) and terrestrial deposits with the Dog Rocks Local Fauna, represent a short-lived late Pliocene transgression. This has its equivalent in the Murray Basin in the Norwest Bend Formation that was limited to the westernmost part of the basin. This was the last marine incursion onto the southern part of the continent. Thereafter Quaternary eustatic transgressions were confined to more coastal districts.

In the Murray Basin late Pliocene uplift of the coastal Pinnaroo block provided a tectonic dam limiting the sea and blocking the fluviatile drainage of the Basin. These movements impounded the lower drainage of the basin's trunk stream (the Murray) and lacustrine claystone (Blanchetown Clay) accumulated in this large lake during late Pliocene through the early Pleistocene time (essentially the duration of the Matuyama Chron, An *et al.* 1986). Wet sclerophyll vegetation again occupied the eastern Murray Basin, responding to the humid conditions engendered by the large lake, itself mimicking the climatic effects of a marine transgression. Fluviatile sand bodies reached into the lacustrine deposits as the lake

level rose and fell in response to climatic perturbations. One of these fluviatile units (collectively the Chowilla Sand) contains the Bone Gulch Local Fauna of late Pliocene age. By the early Pleistocene rainfall diminished, evaporation rates increased and dolomitic limestones (Bungunnia Limestone) were deposited in the western part of the lake basin before an outlet was finally formed and the lake drained at about 0.7 Ma. The resulting increase in gradient entrenched the Murray River in its present course. Falling groundwater levels provided large expanses of unvegetated terrain that were available to aeolian processes under the increasingly drier and more seasonal climates of the Quaternary. As forest cover dwindled in the Pleistocene, woodland and grassland/herb fields developed as precipitation fell to modern values and beyond (Martin 1987). A fossil vertebrate record of this span of environmental change has not yet been found in the Murray Basin, the record continues there in the late Pleistocene after a substantial hiatus.

In the coastal district of Victoria late Pliocene through medial Pleistocene mammal faunas are present, and although the evidence is still sparse, it gives insight into the faunal changes during a span of important environmental change beyond that recorded in the Murray Basin. The Limeburner's Point and Hine's Quarry local faunas show that taxa common to the Late Pleistocene faunas of southeastern Australia already formed communities in the medial Pleistocene and continued through the rest of the Pleistocene without major change. Only the sthenurines seem to show increasing diversity of form as though this 0.7 M.y. span was a period of intense speciation.

Comparative palaeoenvironmental evidence is also available from the circum-Antarctic ocean (Hodell and Venz 1992 and references therein) and the Antarctic continent itself (Ishman and Rieck 1992 and references therein) covering the Pliocene and early to medial Pleistocene. These data indicate that the early to medial Pliocene seas were relatively warm with high sea-levels drowning coastal valleys in Antarctica and corresponding to the transgressive phase of Pliocene history in southeastern Australia. At approximately 2.6–2.4 Ma, at the beginning of the late Pliocene, a significant shift in $\delta^{18}O$ of both planktic and benthonic foraminifers toward positive values heralds the beginning of a major cooling in Antarctica, an event coincident with the initiation of the first major build-up of ice at high latitudes in the northern hemisphere. The resulting sealevel drop is recorded as the post-Kalimnan regression in southeastern Australia. Cooler climates marked the demise of significant tropical rainforest in southeastern Australia and the return to temperate sclerophyll vegetation on the coast and more open formations inland. This early glacial-interglacial cycling was of irregular frequency allowing minor transgression (Werrikooian) in southeastern Australia, but by 1.4 Ma, in the early Pleistocene, a strong 0.041 M.y. cycle becomes evident in the $\delta^{18}O$ signal and this feature, associated with variation in the earth's obliquity cycle, persists throughout the Pleistocene. Thus early in the epoch Australia's biota was subjected to the climatic oscillations that were to typify the Pleistocene. Direct evidence of these cycles from the continent is woefully incomplete, but significant mountain glaciation in Tasmania reaches into the Matuyama Chron (Colhoun and Fitzsimons 1990) in agreement with the limits of such effects as determined from Antarctica.

Conclusions

Improved chronological resolution of the Pliocene and Pleistocene mammal-bearing deposits of southeastern Australia permits determination of the temporal succession of taxa and assessment of the zoogeographic and ecological significance of their occurrence. More comprehensive palaeomagnetic data, calibrated mostly by reference to radioisotopically dated flows of the Newer Volcanic field in Victoria, and more limited data from the Murray Basin, provide a chronology for the faunal succession from early Pliocene into medial Pleistocene time. Nowhere else in Australia is such a detailed representation of this interval to be found. Despite the preservational, taphonomic and palaeoecological biases of the record, it provides the best documented model of mammal faunal change at the end of the Australian Cainozoic.

Early Pliocene faunas in both the Murray and Otway Basins have greater affinity with Pleistocene and Holocene faunas than they do with known Miocene assemblages. Younger strata within the Pliocene transgression show many genera that represent the earliest members of lineages that persist through the Pleistocene and into the Holocene. In that sense the 'modern' fauna appears in the fossil record at the beginning of the Pliocene, but for some genera, their evolutionary appearance may considerably predate this first local appearance as suggested by the

Curramulka Local Fauna (Pledge 1992) of nearby South Australia. The late Miocene hiatus in the southeastern Australian basins limits opportunities to discover the actual historical record there.

Early Pliocene faunas of southeastern Australia contain several genera that appear not to be members of younger assemblages including the diprotodontid **Euowenia*, the potoroid **Milliyowi*, the macropodine **Kurrabi* and perhaps the ektopodontid **Darcius*. During the span of the early Pliocene the genera **Zygomaturus*, **Diprotodon*, and **Propleopus*, appear in southeastern Australia along with species, some extinct, of the living *Antechinus*, *Sarcophilus*, *Vombatus*, *Trichosurus*, *Thylogale*, *Macropus* (*Notamacropus*), *Wallabia*, *Hypsiprymnodon*, *Dorcopsis*, *Dendrolagus*, and *Strigocuscus*. The latter four rainforest genera are unrecorded in later deposits in southeastern Australia, and the co-occurrence of species of some of these living genera represent associations unknown in living faunas. The early Pliocene marine transgression in the Murray Basin and coastal basins of Victoria brought humid conditions onto the continent and rainforest was present in southeastern Australia.

Medial Pliocene regression restored continental environments to the Murray Basin and species of the living *Dasyuroides*, *Satanellus*, *Lasiorhinus*, *Bettongia*, *Macropus* (*Osphranter*), *Petrogale*, *Lagostrophus*, *Notomys*, *Leggadina* and *Leporillus* appear in response to drier environments. Establishment of a large lake system in the western and central part of the Murray Basin in the medial Pliocene allowed wet sclerophyll vegetation to invade the basin. These conditions persisted into the early Pleistocene before the lake system was drained and drier shrubland vegetation became more widespread.

The late Pliocene and early Pleistocene appears to have been a time when living species, or forms close to them, appear in the coastal regions. Species such as *Vombatus ursinus*, *Wallabia* sp. cf. *W. bicolor*, *Macropus* (*Macropus*) *giganteus*, *M.*(*M*) *fuliginosus* and *M.* (*Notamacropus*) *irma*, or closely allied taxa, appear in the late Pliocene. By the beginning of the Pleistocene a number of extinct species appear in the coastal region, *Sarcophilus *laniarius*, **Diprotodon optatum*, **Zygomaturus trilobus*, **Thylacoleo carnifex*, **Protemnodon anak* and *Macropus *titan*, all of which persist through the Pleistocene as the characteristic large mammal suite in most Quaternary assemblages.

The 'modernization' of the mammal fauna during the late Pliocene to early Pleistocene interval corresponds with the increasing continentality of southeastern Australia and to the climatic changes toward modern environments that are observed world-wide as the rate of glacial-age climatic cycling begins to increase. The faunal turnover at the close of the Pliocene, roughly coincident with the initiation of bipolar glaciation, also introduced taxa into the region that had no close relatives there and that seem to be immigrants from drier environments already established elsewhere. Earlier Pliocene histories for some of these [e.g. *Lagorchestes*, *Macropus* (*Macropus*) and *Macropus* (*Osphranter*)] are present in inland Australia. Later in the Pliocene and Pleistocene environmental contrasts between coastal and interior southeastern Australia yield zoogeographic patterns similar to those of the present-day.

Acknowledgments

This synthesis would have been impossible to advance without the kind interaction with Dr. Mick Whitelaw whose work provided the crucial data. His generosity in keeping me informed of his results in advance of publication allowed timely preparation of this work. Reviewers also materially helped the presentation, especially Dr. Alex Baynes, whose careful critique helped sharpen the paper and remove inaccuracies in the original work.

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STUDIES OF THE LATE CAINOZOIC DIPROTODONTID MARSUPIALS OF AUSTRALIA. 4. THE BACCHUS MARSH DIPROTODONS — GEOLOGY, SEDIMENTOLOGY AND TAPHONOMY.

JOHN LONG & BRIAN MACKNESS

LONG, J. & MACKNESS, B. 1994. Studies of the late Cainozoic diprotodontid marsupials of Australia. 4. The Bacchus Marsh Diprotodons – Geology, sedimentology and taphonomy. *Rec. S. Aust. Mus.* **27**(2): 95–110.

The remains of at least twenty individuals of *Diprotodon* were excavated from the Hine's Quarry Fossil Site near Bacchus Marsh, Victoria over the 1973 and 1979 field seasons. Sediments entombing the fossils consist of closed framework sands and grits with interspersed clay lenses, which sit on top of the Tertiary Werribee Formation. Sedimentary structures and comparison with recent sediments of the area indicate that the depositional environment was the proximal part of a low flow regime, ephemeral run-off system, containing intercalated erosional screes suggestive of times of non-hydraulic influence. Bone orientations are related to channel morphology with minimal hydraulic action responsible for poor sorting into Voorhies groups. Bone surface textures and fracture patterns indicate possible carnivore gnawing and prolonged subaerial exposure in an arid climate. Articulated skeletons are common in the proximal area of the bone bed with reworked skeletal material distally. Regional lithologies were reviewed with respect to their contribution to the bonebed.

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The remains of diprotodontid marsupials are commonly found in the Late Cainozoic deposits of Australia but normally comprise isolated elements such as jaws, limb bones or teeth. Whole skeletons including skull and mandibles are a much rarer occurrence but a number have been recovered including those of *Diprotodon* from Lake Callabonna (Tedford 1973; Pledge 1993; Tedford 1993); *Zygomaturus* from Mowbray Swamp (Scott 1915); *Euryzygoma* from the Bluff Downs Local Fauna (Mackness unpublished information) and *Neohelos* from Bullock Creek (Tom Rich pers. comm.).

A number of *Diprotodon* bones were first discovered at Hine's Quarry, 9 km south-west of Bacchus Marsh, central Victoria, in 1973 by Miss Kerry Hine. Subsequently the Museum of Victoria (then the National Museum of Victoria) began excavating a rich concentration of largely articulated *Diprotodon* skeletons, lead by Thomas Darragh and K. Simpson (Monash University). In 1979, further bones were uncovered by quarry work. Periodic field work was resumed under Dr. Tom Rich, Museum of Victoria up until December 1979 when the bone bed was completely dug out. During this time bone elevations and orientation relative to two fixed datum points were measured, and sediment samples were taken from the bone bed and its surrounding outcrops, for detailed analysis.

Rich (1976) regarded the Hine's Quarry site as probably a channel deposit, and from comparison with the present level of the Parwan Valley suggested that the site could be relatively old. The only age control on the site is the Newer Basalt which is present within the fossil bearing sediments as cobblestones. The Newer Basalt lies above other lava flows in the region. The oldest of these flows has a maximum date of 4.03 million years (Rahman & McDougall 1972), thus giving a maximum age range for the deposit as somewhere from Pliocene to Recent.

This paper reports on the taphonomy of this fossil site, examining broadly the geological and biological factors which indicate the possible cause of mortality and subsequent prediagenetic events leading up to the death assemblage uncovered in the quarry. It is based largely on the work of Long (1979, Monash University 3rd Year field project). Future papers by Mackness will discuss the taxonomy and tooth variation of the Bacchus Marsh *Diprotodon* site as well as its associated microfauna. Few taphonomic or palaeoecological studies of Australian Pleistocene mammal sites have so far been carried out (Horton 1976; Horton & Samuel 1978; van Huet 1993).

Methods

Bone orientations were measured by compass bearing to the long axis on each bone. Elevation was measured using a plastic tube filled with a dark liquid. The end of this tube was tied to the datum pipe, with the level marked and then a measuring pole placed on the bone. The free end of the tube was moved up or down until the marker level on the datum pipe was achieved, and then height of fluid level was measured above the bone and recorded.

Field mapping was carried out in the immediate vicinity of Hine's Quarry, and sediment samples were collected from nearby ephemeral streams and eroding gullies for comparison. Sedimentological studies were carried out by standard dry sieving procedures, thin sectioning, and differential thermal analysis (DTA), the latter carried out at the Mineral Physics Laboratories of the CSIRO, Port Melbourne. Bone surface textures were studied with the aid of a scanning electron microscope, and analysis of the composition of fossil and fresh marsupial bone was determined by use of an electron microprobe. Sedimentological methods follow those of Folk (1961). The orientations of bones collected during the 1973 field season were determined from a series of detailed photographs taken by Ian Stewart. Abbreviations for specimen/sample numbers: P, Museum of Victoria; #, Field Number; MG, Monash University Department of Earth Sciences.

Geology

Hine's Quarry is situated in the south-eastern corner of the sunken Ballan Graben, which forms part of the uplifted block on the west of the Rowsley Fault, bounded to the south by the Brisbane Ranges, and to the north by the

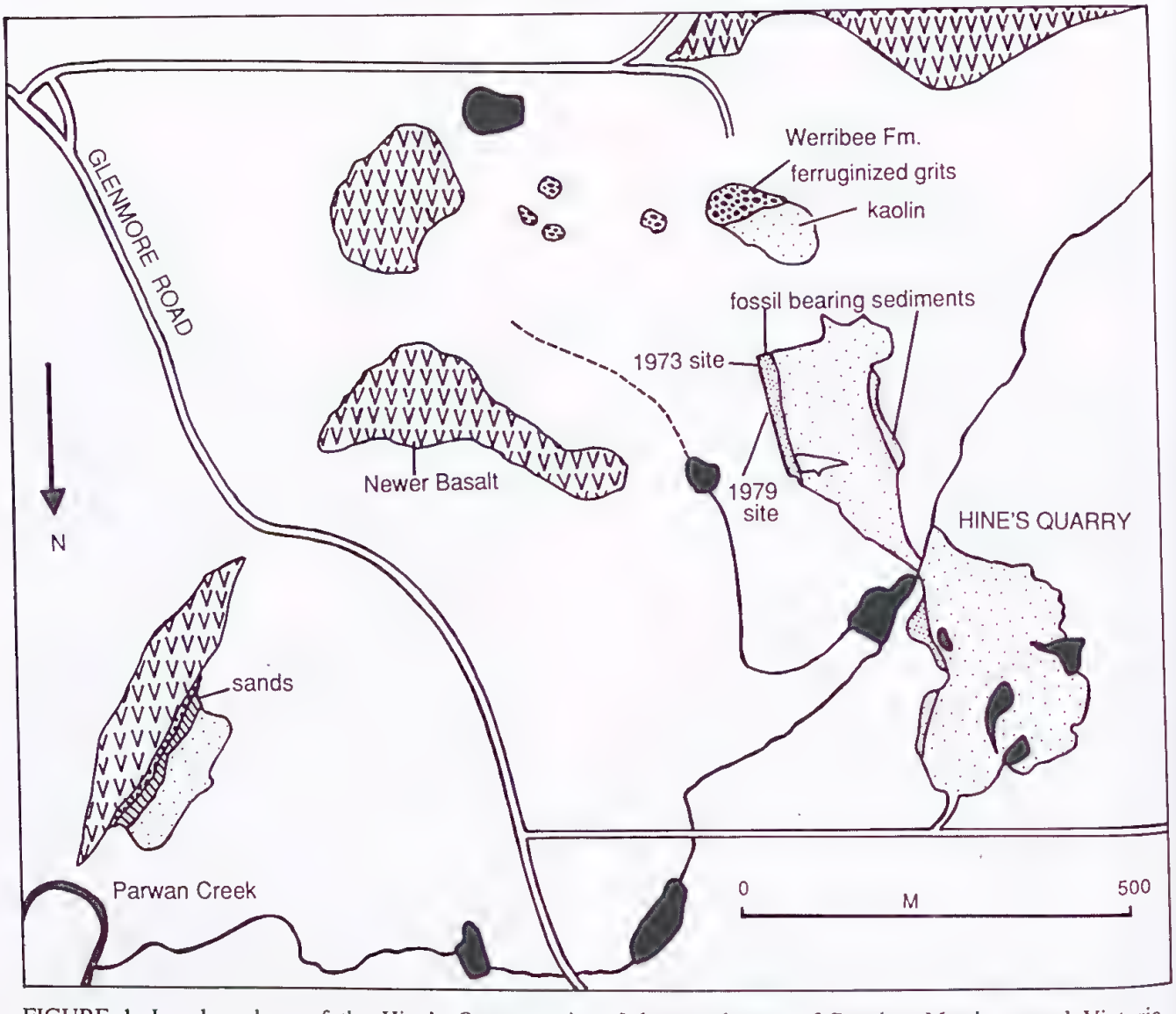

FIGURE 1. Local geology of the Hine's Quarry region, 9 km south-west of Bacchus Marsh, central Victoria, Australia.

FIGURE 2. View of Hine's Quarry fossil excavation (arrow points to main bone horizon), looking east from the south-western corner of the quarry.

Lerderderg Ranges (Fenner 1918; Summers 1923). Parwan Creek and Werribee River cut into the soft clays and sandy clays of the Werribee Formation (Thomas & Baragwanath 1950; then called the Yaloak Formation), draining to the eastern lowland of the Werribee Plains. The fossil site (Fig. 1) is situated close to the Rowsley Fault which is post-Pliocene in age based on the evidence of faulted Newer Basalt dated at 4.03 million years (Rahman & McDougall 1972).

The fossils occur in the south-eastern corner of Hine's Quarry (Fig. 2) in a thin surficial layer of reworked sediments derived primarily from the underlying Werribee Formation. The Werribee Formation is made up of kaolin-rich sediments which (Fig. 3) are distinguished by their low quartz content, absence of basalt inclusions, and more compact texture. Inclusions within the Werribee Fm are infrequent, but quartz pebbles and gravel lenses are present, derived from nearby Permian glacials and uplifted Ordovician flyschoid sediments. Two important units of the Werribee Formation are exposed near the fossil site, both which have contributed to the composition of the fossiliferous sediments. The age of the Werribee Formation is tentatively placed as being Paleocene to Mid Miocene based upon microflora from the Lal-Lal coal deposit (Cookson 1954, 1957), and relationships with the older basalts (Wellman 1974). Exposed portions of the Werribee Formation at Hine's Quarry are not fossiliferous.

Ferruginized grits are exposed to the south of Hine's Quarry, forming 'Hine's Hill'. These are closed framework quartzose, coarse sandstones and gravels, representative of fluviatile channel sediments with interspersed minor conglomerates and cross-bedded sandstones. The unit exposed at Hine's Hill is approximately ten metres thick. The top of this unit is capped by recent, relatively unconsolidated fluviatile conglomerates. The ferruginized grits sit conformably upon the fine kaolinites exposed in the quarry. No basalt caps Hine's Hill, it being of higher elevation than the surrounding basalt plain.

At Werner's Quarry, one kilometre east of Hine's Quarry, the ferruginized grits are seen above the kaolin and below the Newer Basalt flows, confirming that this unit is included within

FIGURE 3. Contact between reworked fossiliferous surface sediments and Tertiary Werribee Formation kaolin (arrow indicates unconformity). Note coarse basal gravels containing large basalt cobblestones.

the Werribee Formation. There are palaeosols and laterite with accretionary structures, roughly spheroidal and inwardly zoned, between the grits and basalt. This resembles the Timboon terrain in the Parwan valley (Gill 1964).

Sedimentology

Although fossil bones were found at two sites within Hine's Quarry, the main concentration came from the south-eastern corner, the subject of this study. Another locality, 'Ian's Site', has produced a few bones from the top of the south-west face of the quarry. Both sites involve similar lithology and are probably contemporaneous.

The sediments entombing the main bone concentration comprise discontinuous layers of clay-rich closed framework sands, gravels and silts (Fig. 4). They represent a mixture of both depositional and diagenetic events. Large basalt cobblestones occur randomly throughout the deposit, either as isolated stones without associated gravel, or within small conglomeratic lenses.

Below the bone-bearing sediments is the disconformable contact with the kaolinitic clays of the Werribee Formation, and above the unit are recent river terrace conglomerates, so close to the subsurface as to be incorporated as regolith. The fossiliferous unit is up to 3.3 metres thick at the distal end of the bone concentration. The concentration of *Diprotodon* remains form the only marker horizon within these sediments, although spasmodic isolated bones (generally macropodid remains) randomly occur at all stratigraphic levels.

Several profiles through the unit were measured and described. The discontinuity of sediment layers can be clearly seen from these sections (Fig. 4). Sedimentary structures were generally absent apart from horizontal discontinuous stratification, lensoidal and festoon cross-stratification. Rarer instances of small scale scour and fill channels, graded laminar bedding, and steep erosional surfaces were encountered. The high clay content of the coarser beds is due to secondary seepage of clay through the open pores of the sand. These sediments are strongly bimodal, and have been analysed with the diagenetically acquired fine fraction omitted.

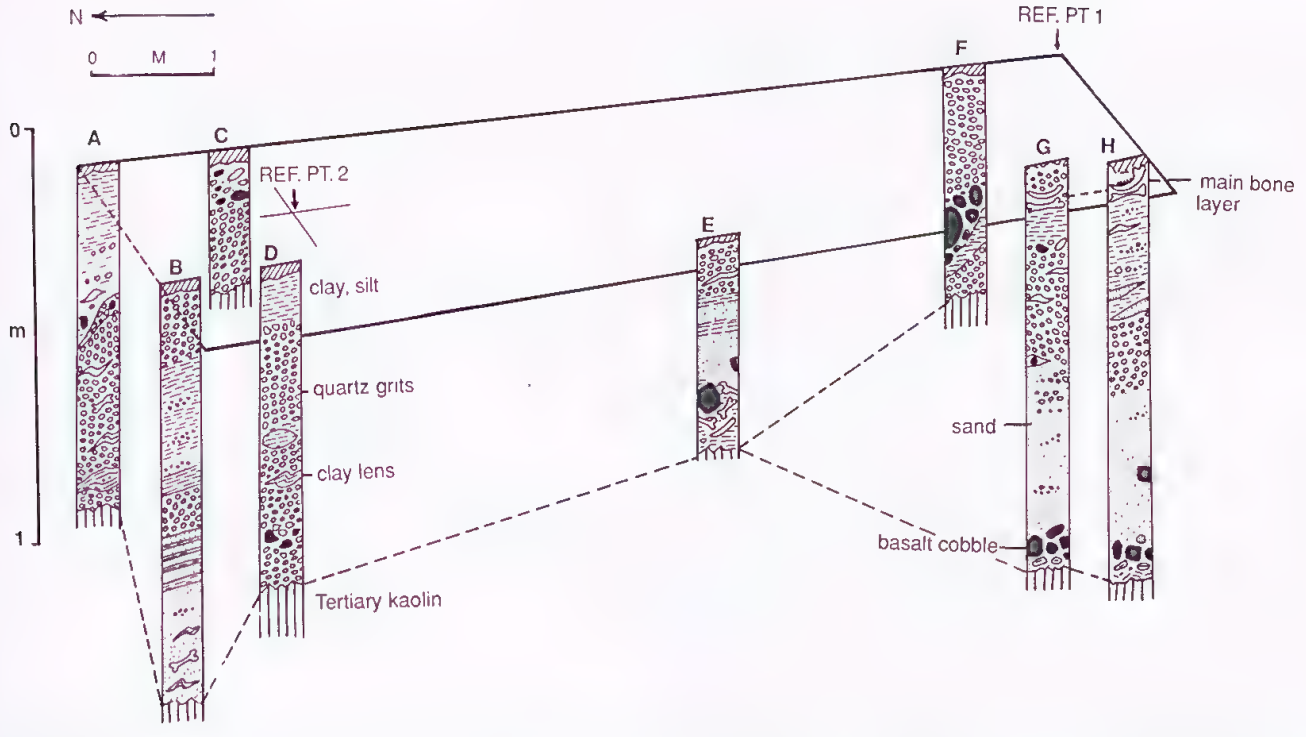

FIGURE 4. Profiles through the bone bed. Distance from Reference Point 1 to Reference Point 2, approximately 14 metres.

The dominant pattern is coarsening upwards, with coarse grits overlain by episodic fine silts and clays. Several depositional episodes are thus represented in the fossiliferous unit. The distribution of large basalt cobble is incongruous with the surrounding fine-grained sedimentary regimes. Apart from obvious association with sediments such as in basal erosional polymict conglomerate, the basalt cobbles elsewhere are randomly distributed. The composition of the basalt indicates it is from the nearby outcropping flows, and is also comparable in terms of deterioration. Smaller basaltic fragments in the fossiliferous unit (<2 mm) are severely altered by kaolinitization, recognisable only by the black specks of ilmenite and magnetite in a clay matrix. The weathered basalt clasts also showed vesicles.

The lowermost sediments of the fossil beds contain appreciable basalt, large pieces of ferruginized sandstone and intraclasts of dense, pure kaolinite. This clearly indicates erosion of exposed Werribee Formation (both kaolinitic clays and ferruginized sandstones) with input from the nearby eroding basalt plain.

Sediments of the bone bearing unit are mostly sand-sized once secondary clay content is extracted. The quartz content is of two types: orange quartz derived from the ferruginized grits, often cemented by iron oxides, and secondly, white quartz derived from the purer Werribee Formation clays. The latter is hydrothermal quartz eroded from Ordovician sediments of the Brisbane and Lerderderg Ranges. Rare grains of plutonic quartz are also present. The quartz is mostly subangular. The only particles exceeding 20 cm diameter are basalt cobbles or *Diprotodon* bones. A typical section through the bone bed (Section E, Fig. 4) shows that the fossiliferous sediments are poorly sorted, platykurtic, near symmetrical medium to gravelly sands, with a 41–73% kaolin content.

Hypothetically the ferruginized grits capping Hine's Hill eroded back away from the quarry by gullying, leaving steep, rilled, erosional faces. The base of this scarp has a build up of talus sediment. Sediments from the eroding gully talus and ephemeral valley stream near the quarry were analysed for grainsize and composition (Figs. 5,6). The gully sediments are poorly sorted, mesokurtic, near symmetrical sandy gravels (Mz= –0.98) on top with poorly sorted leptokurtic coarsely skewed medium to fine sands below (MZ=1.32–1.92). The ephemeral stream sediments are poorly sorted, near symmetrical, mesokurtic very coarse sands with appreciable (28%) gravel. A sample of surficial sediment from the quarry floor was also analysed, indicating a poorly sorted, near symmetrical platykurtic medium sand.

In all analyses the clay and silt fractions are very low. Sediments closest to the surface are

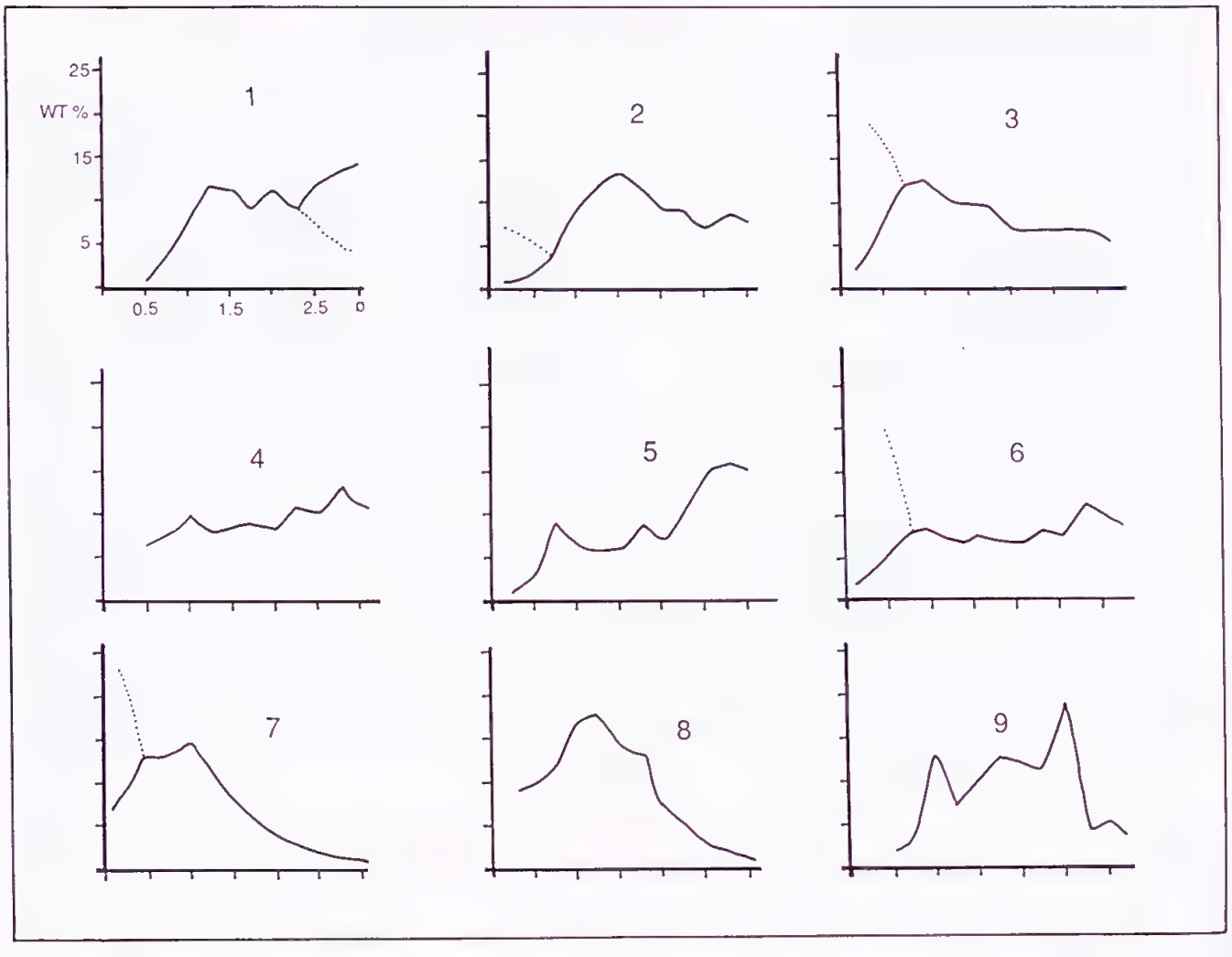

FIGURE 5. Sediment analyses from the bone bed (1–5), basement Tertiary Werribee Formation (6), and recent sediments near the fossil site (7–9). All to same scale, equal to axes of graph 1. Dotted lines indicate exclusion of secondary fine clays. All MG specimens: **1**, –59442; **2**, –59443; **3**, –59444; **4**, –59445; **5**, –59441; **6**, –59440; **7**, –59438 (ephemeral tributary stream to the Parwan Creek); **8**, –59434 (gully talus sediment); **9**, –59439 (surface scree from quarry floor).

coarser and less sorted. Subsurface transportation of the kaolinitic fraction apparently occurs rapidly after erosion. The steep gradient of the bone bed, and the sedimentological analyses, indicate that the bones were deposited in an eroding gully and covered by surficial scree sediments and ephemeral run-off sediments, identical with those analysed from the vicinity of the quarry.

The shallow depth of the fossiliferous unit, together with its orientation parallel with the topographic surface, suggests it is a relatively recent accumulation, accruing over time by numerous episodic depositional events. Study of the bone surface textures (next section) supports the hypothesis that the surrounding sediment deposition was not a result of high energy, continual processes, but slowly accumulating processes. This would allow time for the bones to be subaerially exposed for a prolonged period of time and weather prior to burial.

Taphonomy

Bone orientation data and interpretation

Stereographic projections, equal area net, (Phillips 1971) of bone long axis (poles to bones) for the 1978–1979 excavations revealed no overall trends (Fig. 7). When proximal (upslope end), central and distal sections of the bone bed were examined separately a weakly defined trend was seen for the distal end of the main *Diprotodon* concentration as bimodally directional. This indicates that the highest degree of hydraulic sorting occurred at this end, that is the furthest downslope area from the proximal concentration of skeletons. The information is derived from small fragments of bones, mostly rib pieces of similar size and shape. This suggests that although a small degree of current sorting occurred here the orientation of bones forming the

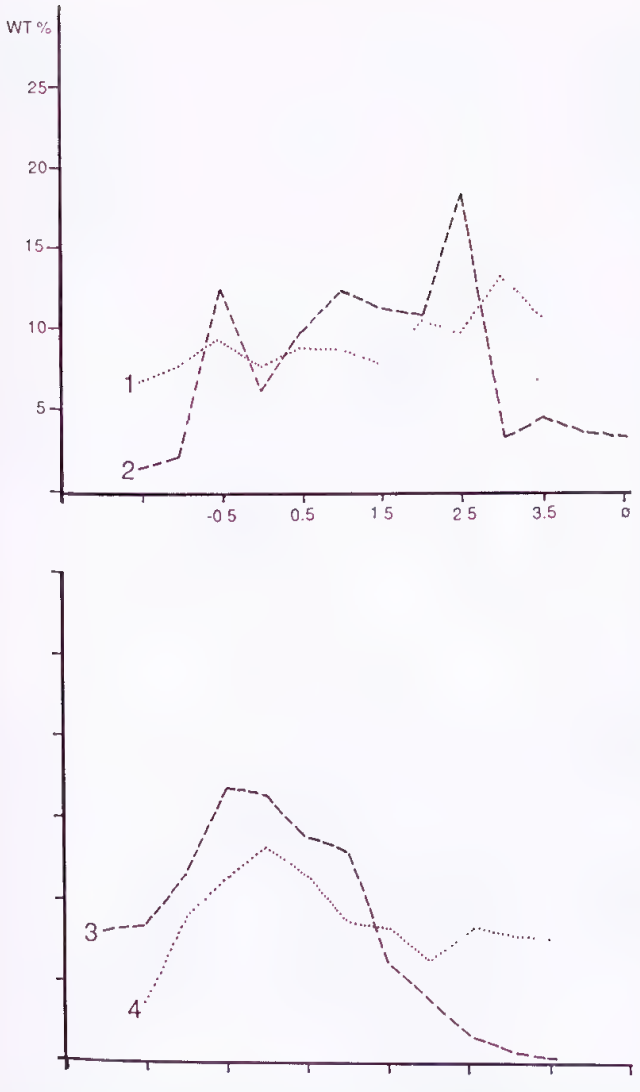

FIGURE 6. Comparison of recent sediments (2,3) with sediments of the fossil bed (1,4). All MG specimens: **1**, –59445; **2**, –59439 (surface scree, quarry floor); **3**, –59443; **4**, –59438 (ephemeral stream).

major portion of the bone bed was not influenced by hydraulic processes. Fig. 8 shows the overall plot of bone positions both horizontally and vertically in the bone bed, based on data from the 1979 dig.

Voorhies (1969) demonstrated that the bones from animals larger than sheep will act responsively to given hydraulic regimes, resulting in a sorting of bone groups from proximal to distal ends of stream flow. 'Voorhies groups' are associations of skeletal elements with similar hydrodynamic transportational properties. Group 1 contains vertebrae, ribs, sacra and sterna, and are considered the most easily transported, either by floating or saltation. Group 2 contains mostly limb elements, and group 3 contains the least mobile bones such as skulls and mandibles. Elements of group 2 move by traction whereas group 3 elements are chiefly lag components, which remain closest to the site of death. Examinations of the distribution of Voorhies groups for the Hine's Quarry *Diprotodon* bed shows a concentration of 95% of group 3 bones at the proximal end of the bone bed. Most of the skull and jaw elements were closely associated. Fig. 9 shows a plan of bones from the central part of the bonebed reflecting the orientation of bones with respect to channel morphology. The individuals were very close to one another at the final place of deposition (Figs 10,11).

The roughly sequential array of Voorhies groups seen in the bone distribution map suggests only a minor degree of hydraulic transportation. The bone orientation data and sedimentological evidence indicates that ephemeral stream flows, of high energy but short duration, carried the partially articulated skeletons from the place of death to the main burial site. Subsequently erosional screes covered the exposed skeletons. The absence of large numbers of group one elements (for at least 22 individual *Diprotodon)* further supports the influence of rapid water flows for short durations, carrying most of these lighter bones away from the area which was excavated.

Bone orientations (Fig. 7) are generally horizontal to shallow plunging throughout the fossil bed, except for one localised concentration of steeply plunging associated macropodid bones in the north-eastern boundary of the bone bed. These bones rested in unstable positions with respect to gravity.

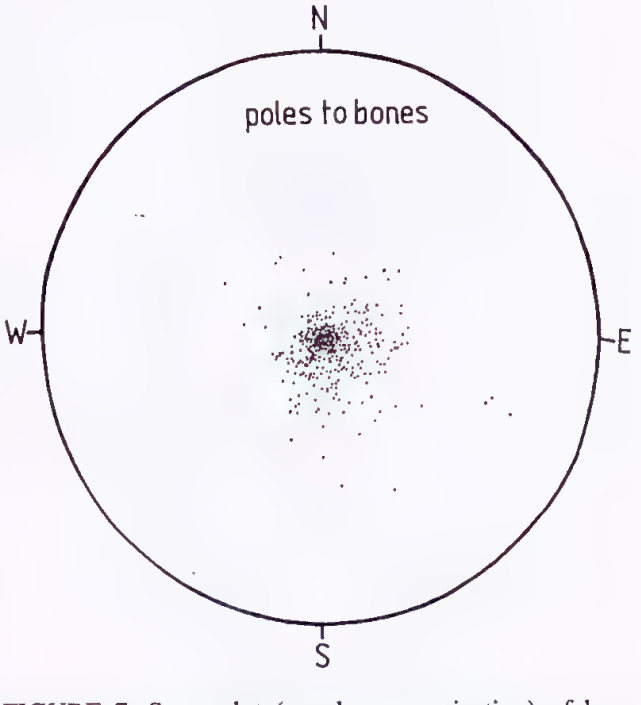

FIGURE 7. Stereoplot (equal area projection) of bone orientation from the 1978–1979 excavations. Note cluster of shallow dips and lack of bimodalism.

The high degree of bone articulation combined with their orientation suggests a separate episode from that of the original *Diprotodon* bone accumulation. Hypothetically a carcass dumped into an irregular erosional gully, somewhat like a pothole would produce a similar effect. Many of the isolated macropodid bones or partial skeletons occur at a different depth to the main *Diprotodon* bone horizon (Fig. 8) and are clearly separate burial events.

A contour map of the surface on which the bones were deposited was constructed (Fig. 9) from the elevations of the lowest bones in the main concentration of the bonebed. The channel (or channels) in which the bones were buried had an irregular morphology, often with V-shaped embayments upslope. The channel bottom was notched with local low and high spots. When bone orientations are studied in view of channel morphology it would seem that this factor had the strongest influence on the resting positions of bones. Bones caught in localised lows or runs have stronger preferred orientations according to the downstream flow of the channel than those dumped upon broad flat areas of the channel. High points are invariably devoid of bones.

Bone orientations are most easily explained in terms of channel morphometry, without indication of significant current sorting, save for the extreme distal area of the bone bed. Sorting into Voorhies groups indicates spasmodic, short durations of concentrated high flow regimes, possibly flash floods washing carcasses down the gully channels. The main proximal concentration of articulated skeletons did not move far from the site of death, as indicated by their fine preservation and high degree of articulation.

The distal end of the bone bed terminates at the quarry scarp, and hence a large number of Voorhies group 1 elements are presumably missing from the excavated area having been washed away. The bone distribution map shows that there is a high density of bones proximal to the truncation of the bone bed,and it can be safely assumed that most of the fossil remains of Voohries groups 2 and 3 were recovered by the excavations.

Bone preservation and articulation

Most of the bones have poor preservation, being soft and crumbly due to preburial weathering and diagenesis. Exposure of the bone before burial results in steady decomposition according to localised conditions (Behrensmeyer 1978; Behrensmeyer *et al.* 1979). The degree of bone surface decomposition ranges from Type 1 (Behrensmeyer 1978) (seen only in the proximal

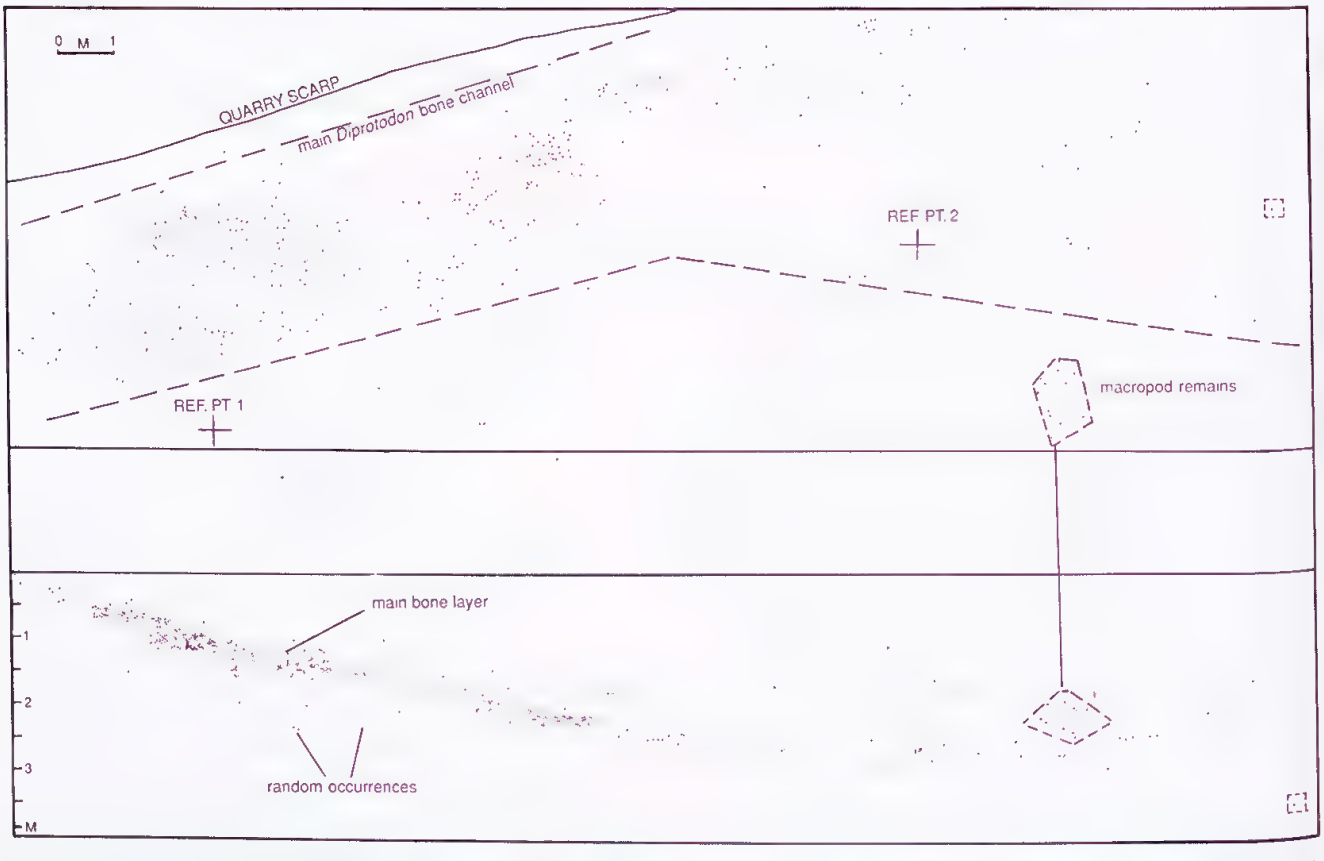

FIGURE 8. Distribution of bones from the 1978–1979 excavations. Top, plan view showing proximal channel outline. Bottom, depth of bone distribution.

region of the bone bed) to almost completely decayed pieces of bone, where the surface has been lost, showing only the spongy trabecular bone. Overall, most bones show surface flaking and cracking parallel to bone fibre, with a small degree of exfoliation of the outer surface, corresponding to Types 2 to 3 of Behrensmeyer's scale (Fig. 13: 3,4). Comparison with the results from the Amboseli basin of Africa suggests that such bone has undergone prolonged exposure to arid climatic conditions.

Moisture accelerates bone decomposition, and

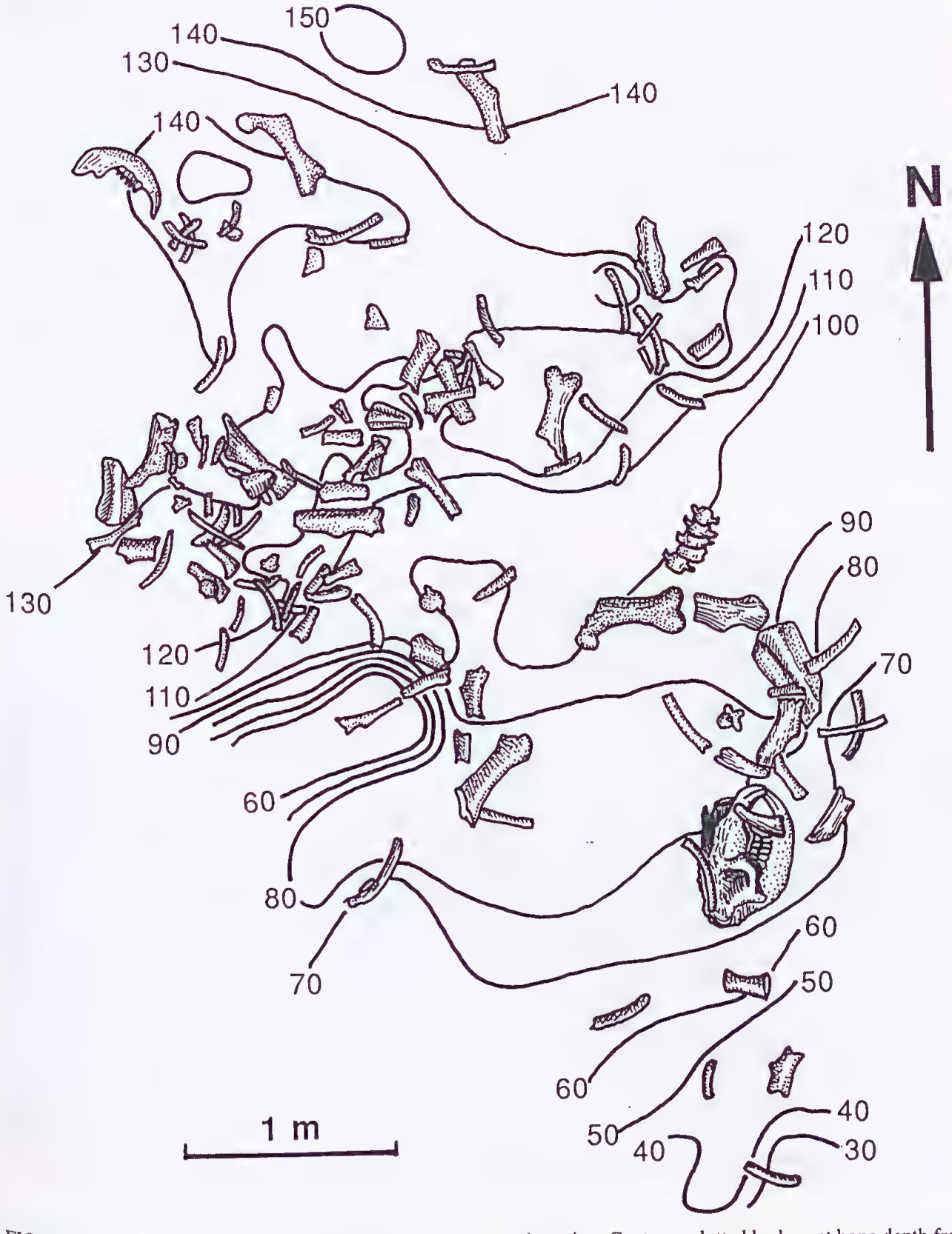

FIGURE 9. Channel morphometry shown in relation to bone orientation. Contours plotted by lowest bone depth from main concentration, bone orientations and preservation correctly shown.

FIGURE 10. Photograph from the 1973 excavation at the extreme proximal portion of main bone bed. Note excellent preservation, dense concentration and partial articulation of bones. Photo courtesy Ian Stewart.

FIGURE 11. Partially articulated skeleton in the proximal area of the bone bed, 1973 excavation. Photo courtesy Ian Stewart.

FIGURE 12. Bone preservation from the main bone bed. Seventeen *Diprotodon* femora showing degree of completeness and approximate state of surface condition.

decay of skeletons in temperate to tropical environments results in different styles of bone deterioration (Behrensmeyer 1975). Separate teeth of *Diprotodon* from the distal area of the bone bed show fractured roots and streaking of the enamel (Fig. 13: 1,2). Root fracturing is due to transportation, with significant preburial exposure causing enamel streaking and eventual splitting (Behrensmeyer 1978).

In general, the bones are recovered in variable states of preservation and degrees of articulation. The most proximal end of the bone concentration (1973 dig) shows a high degree of articulation, and relatively good preservation of bone surface (Figs 10,11). Articulation is not complete in any instance, the most complete skeletal remains comprise of skull, mandibles, vertebral column, parts of the limbs, shoulder girdle, pelvis and feet, not all articulated, but in close proximity. Skulls in the proximal area of the bone bed were often turned over, and one mandible was upside down resting in a steep position. Limb bones were always lying flat, as were scapulae and pelves. The strongly curved nature of the articulated vertebral column (Fig. 11) could indicate bending due to ligament contraction following drying of the carcass. The high number of skulls and mandibles recovered from this area, and the high degree of postcranial articulation, relative to that seen in the distal end of the bone bed suggests close proximity to the place of death.

The distal end of the bone bed is composed of non-articulated limb and rib pieces, in variable state of preservation. Skulls and jaws were concentrated at the proximal end of the bone bed. One isolated skull was found very close to the distal end of the bone bed, and had presumably rolled down. Sections of articulated *Diprotodon* vertebral column were found only in the proximal half of the 1978–1979 excavation.

To conclude, the overall degree of articulation shown throughout the bone bed is not indicative of a natural trap or catastrophe in which animals are rapidly entombed whole (e.g. bogging, pitfall) but suggestive of mass mortality followed by exposure and some degree of transportation. At the proximal end of the bone bed some part of the skeletons were buried rapidly and show good surface preservation. The majority of the carcasses were disarticulated and moved slightly downslope.

Condition of the bones

Since the sediments of the bone bed were rich in kaolinitic clays, the diagenetic environment was basic (a solution of distilled H_2O with sediment MG 59443 was slightly basic, pH=7.5, although when made into a mud slurry with little water pH=9). High porosity of the grits in the bone bed enable concentrated basic condition for bone decomposition.

Microprobe analyses of fossil bone and tooth fragments from the bone bed show a slight increase in calcium oxide content, a decrease in

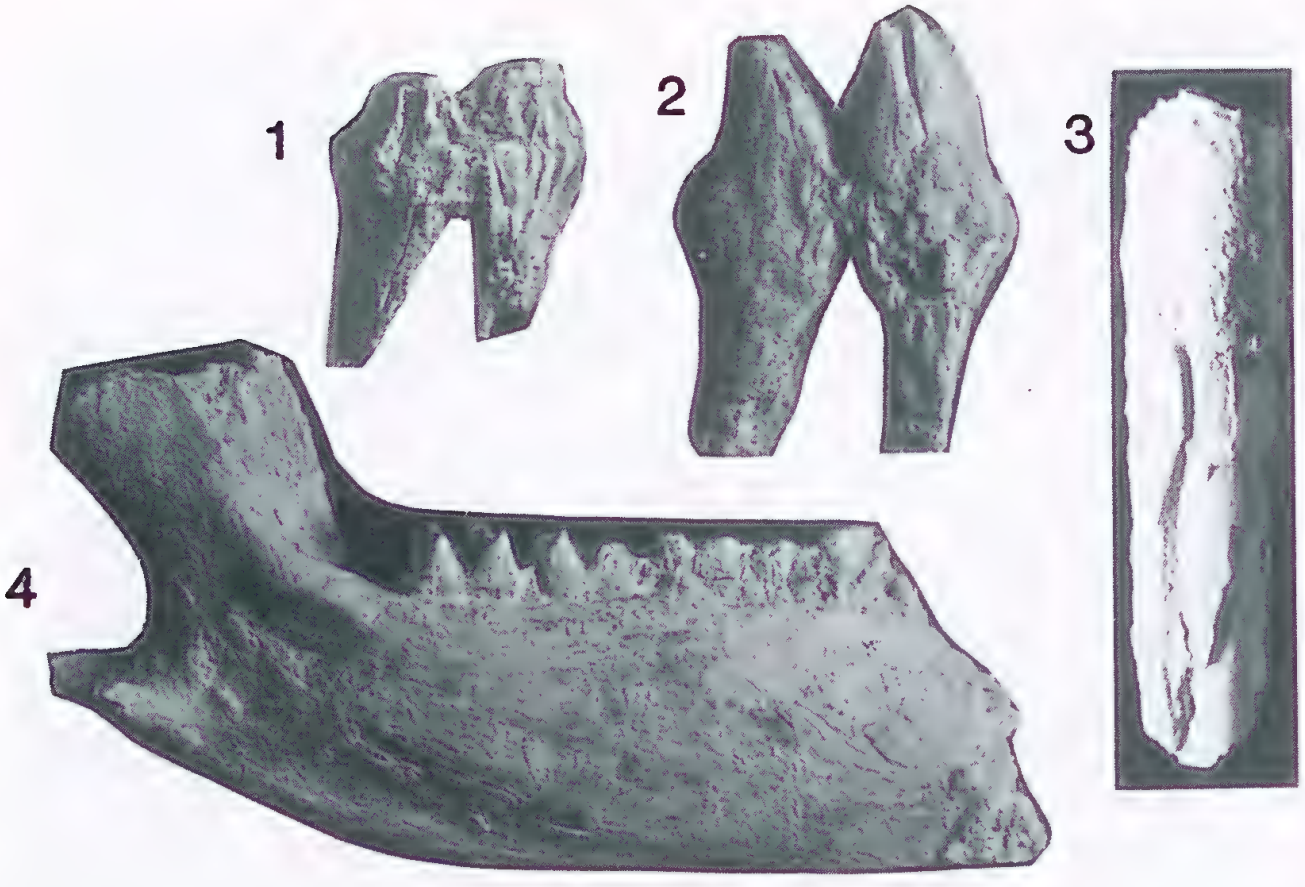

FIGURE 13. Bone preservation. **1–2**, Isolated *Diprotodon* molars (no numbers) showing enamel streaking and splitting, with transportational abrasion to roots; **3**, Highly weathered splinter of macropodid bone, showing parallel surface exfoliation, splitting and fracturing; **4**, Macropodid jaw from the distal end of the main *Diprotodon* concentration. Note excellent preservation of posterior molars with splintering of premolar and anterior two molars. The ramus shows preburial exposure cracking and flaking, with transportational breakage to diastema and ascending ramus.

phosphoric oxide P_2O_5 with chloride salts added at 2–3% (relative to probed samples of modern *Macropus* bone and teeth). This indicates that the bones lacked mineralisation because of constant leaching or disappearance of available calicum oxide. Drying and wetting of the clays around the bones may have caused diagenetic fracture by swelling and compaction as host rock volume changes. Many bones had a coating of a black mineral presumably manganese salts.

Very few bones were preserved in their entirety, although those that were show only minor abrasive features such as rounding of edges. Vertebrae with entire neural arches typify this state, although they show gentle rounding of extremities. In a study of carnivore gnawing patterns on recent and Pleistocene mammals, Haynes (1980) documented the individual patterns of damage incurred upon each skeletal element when wolves utilised carcasses of medium to large-sized herbivores. Some of the Bacchus Marsh *Diprotodon* bones demonstrate similar damage patterns to those of bison scavenged upon by wolves.

Out of 28 femora examined only two were completely preserved without wear or breakage, apart from very slight abrasion of the greater trochanter (P 150114, and #94; Fig. 12). Three specimens showed good preservation of the trochlear area but had damaged greater trochanters or were lacking the femoral head. Light utilisation of bison femora by wolves results in damage to the greater trochanter only, followed by damage to the distal condyles and removal of the femoral head during heavy utilisation. The shaft may not be damaged as the end of the bone is softer, enabling easier access to marrow.

The majority of *Diprotodon* femora recovered from the site are missing both femoral head and trochlear region (Fig. 12). Fractures on the distal end of their shafts are screw type (Haynes 1980), suggesting transportation breakage. If gnawing had occurred prior to transportation then rounding of the edges, through abrasion, could have smoothed the jagged edges produced through carnivore action. Evidence of preburial scavenging is seen on some of the tibiae which hypothetically show gnawed off proximal heads (e.g. #67, #164,

#150, P150203).

Haynes (1980) shows articulated humeri with light carnivore gnawing, such as damage to the distal end, rather than the commonly gouged out and broken proximal epiphyses. The *Diprotodon* humeri showed much damage to the proximal epiphyses (#47, #157, #162, #257, #424, P151889, #218). Although no similar studies have been made on Australian carnivores, contemporaneous animals such as *Thylacoleo* were of suitable size and have left fossil evidence of predation on *Diprotodon* and other animals (Horton & Wright 1981; Runnegar 1983). Reptilian scavengers such as the giant varanid *Megalania* should also not be ruled out as contributing to post mortem bone damage.

The main bone concentration contains all the *Diprotodon* bones found, with only few additional macropodid bones, rodent remains and a lizard jaw. All other bones were found at various depths throughout the sediment, not confined to any single horizon or lithology (Fig. 8). A rodent maxilla was found in association with a partial macropodid skeleton in the distal part of the site.

In summary, both the state of bone preservation, bone fracture patterns and the distribution of taxa throughout the sediment suggest that some bones were transported and subaerially exposed longer than others. Different burial events are responsible for the main *Diprotodon* element concentration than for individual macropodid burials.

Bone settling velocities

Behrensmeyer (1975) formulated a method for calculating bone settling velocities in which bones were equilibrated to quartz pebbles sizes. For bones the size of *Diprotodon*, large quartz spheroids would be necessary. For example, a hippopotamus premolar has a quartz spheroid of 13.8 mm diameter as its hydraulic equivalent. Ribs of cows (*Diprotodon* size) require only 3.1 mm quartz equivalents. The flow of water moving the coarser quartz sands and grits of the bone bed may have just reached high enough energies to move ribs, but did not reach velocities capable of transporting larger skeletal elements by themselves. For vertebrae of about 29 cc volume (macropodid size) the hydraulic equivalent is a quartz spheroid of 4.4 mm diameter.

Most bones from the site have a much higher hydraulic stability than their entombing sediments, indicating close proximity and little transportation from the site of death. Movement to the distal area of the bone bed could have occurred either by flotation of carcasses prior to decay, or have been assisted by the high slope gradient of the exposed channel, thus requiring lower flow regimes to achieve higher degrees of transportation.

Biological Data – population structure

At least 22 individual diprotodontids (based on numbers of right femora), all probably representing a single species of *Diprotodon,* were recovered from the site. A number of macropodids were also present as well as a variety of smaller mammalian taxa including rodents, dasyurids and peramelids. Fossils of reptiles have also been recovered.

It is clear from the tooth eruption and wear patterns of the Hine's Quarry *Diprotodon* that most were adults. Of the sixteen mandibles (Fig. 14) examined, most had all molars erupted and the majority of specimens lacked wear on both lophs of the fifth molar. Aged and juvenile individuals are absent.

The taphocoenosis (death assemblage) of the deposit is biased towards similarly aged individuals and excludes the very young and the very old. Such a selection could represent random sampling (normal rarity of juveniles or aged) or a biased selection of the strongest or most active animals. Similar age structure is described by Newsome (1965) in studying the reproduction of female red kangaroos in drought conditions. He noted that fecundity decreases during drought conditions and that adults in their prime constitute the dominant surviving group. The macropodid jaws from the deposit include at least two juveniles (e.g. MV–150120), although it must be pointed out that these apparently represent separate burial episodes from the main *Diprotodon* concentration.

Discussion

Both the sediments of the bone bed and the distribution and orientation of the bones indicate that deposition occurred at the proximal end of an ephemeral stream system. The system envisaged would be at the foot of a series of gullied rilles running from the top of the hill (straighter at the proximal end) to the creek (increasing sinuosity distally). Evidence for this is seen by the discontinuous nature of bedding with lenticular and festoon cross-stratification. The latter indicates fluctuating sedimentary regimes and

moderate to lower flow regime (Dane-Picard & High 1973).

Thin wisps of almost pure clays and silts, occurring randomly throughout the bone bed are interpreted as depressions in the exposed surface where clays settled out of puddles following intense rains. This phenomenon was observed to occur in the quarry during fieldwork when 1–2 cm kaolinitic layers formed at the bottoms of puddles from overnight rain. It is because of the impermeable nature of the kaolinitic basement that the erosion of clays occurs. The presence of large basalt cobbles throughout the bone bed can be explained by collapse and rolling of the nearby eroding basalt plain, hence the irregularity of the cobble size and distribution.

A close relationship is seen between sediments containing the bones and the modern sediments of the area. Mass percentage versus grain-size for some of these are identical. Sediment samples MG 59445 and MG 59439 (Fig. 5, graphs 4 and 9) are both polymodal with 4 peaks each, all corresponding to 1 phi size, most within 0.5 phi. Highest peaks are reached as 2.5 phi for 59439 and 3 phi for 59445. This demonstrates that the sediment containing the bones is little different

FIGURE 14. Sketches of tooth eruption patterns for sixteen individual *Diprotodon* mandibles. Where both sides were present the best preserved tooth is shown. **1**, P151801; **2**, P151802; **3**, P150293; **4**, P32223; **5**, unnumbered; **6**, P15106; **7–8**, unnumbered; **9**, P150017; **10**, P151804; **11**, #492; **12**, P150062; **13**, P150298; **14**, P150299; **15**, #25 (1973); **16**, unnumbered.

from the surface wash scree on the quarry floor (MG 59439, Fig. 6, graph 2) which was derived from erosion of both ferruginized grits and purer sandy clays of the Werribee Formation. Comparison with ephemeral stream sediments near the quarry (MG 59438, Fig. 6, graph 4) indicates episodes of higher flow regime. Both MG 59438 (modern ephemeral stream) and MG 59443 (bone bed; Fig. 6, graph 3) are unimodal with closely spaced highest peaks at –0.5 phi (MG 59438) and O phi (MG 59443). Maxima for these samples are 16.7% and 13.2% respectively. This suggests that the sediment of the bone bed may have had a slightly lower energy of deposition.

The sediments entombing the bones signify a stream or gully system of generally low flow regime and fluctuating deposition. Erosional screes are intercalated with spasmodic higher flow regime channel sediments. Irregular channel morphometry and random bone orientation further supported by the steep channel gradient suggest a juvenile hydraulic system buried the carcasses. In summary the evidence does not favour a regular fluviatile channel environment as first suspected, but an ephemeral erosional system.

The sedimentological data favours an arid climate at the time of deposition. Minimal predator influence corroborates the idea that aridity may have caused the death of a *Diprotodon* herd. Considering that the fossil-bearing sediments are close to the modern ground surface, the topography at the time of the event was probably not unlike the present condition. The eroded scarp of the ferruginized grits on top of Hine's Hill and the basalt would have been closer to the fossil site. The bone bed morphology is comparable to an eroding gully rille presently exposed above the fossil site, and the fact that the bones are channelled along a similar direction to the existing hill topography supports the recency of the event.

Ephemeral hydraulic regimes also support the aridity hypothesis, which would suggest an age for the site at the most recent late Pleistocene glacials (Bowler 1982). The phylogeny of the Diprotodontidae suggested by Stirton *et al.* (1967) restricted the genus *Diprotodon* to the Pleistocene, although the genus is also known from the late Pliocene Kanunka Local fauna (Tedford, Williams & Wells, 1986).

The scenario suggested by the combined data is that the herd of young adult *Diprotodon* expired from a period of severe aridity and drought. The carcasses were subsequently moved downslope after scavenging and extensive subaerial decomposition. The highly basic nature of the entombing sediment pore fluids caused a rapid deterioration of the fossil bones. The evaporation of ground waters during intense aridity resulted in the secondary infilling of kaolinitic clays in the pore spaces of the bone bearing sediments. This infilling was assisted by erosion of clay rich sediments from the surface which seeped downwards between pore spaces in following seasons of rainfall.

Acknowledgments

The initial field work for this study was undertaken as a third year geology project (J.L.) in the Department of Earth Sciences at Monash University in 1979. It was suggested by Tom and Patricia Vickers-Rich who provided useful guidance. Tom Rich also provided the first set of bone orientation readings from the 1978 field season. Tim Flannery, Rob Glenie, Ian Stewart, Thomas Darragh, Dominic Williams (now deceased), Arthur Day, John Clemens, Greg McNamara and Robert Baird provided assistance and discussion on many aspects of the work. Ian Stewart made a series of panoramic photographs from the 1973 field season available for study. John Hamilton (CSIRO Mineral Physics, Port Melbourne) facilitated the use of a scanning electron microscope and DTA equipment for study of clay samples and bone surface condition. Mr. A Taylor kindly provided accommodation during field work, and the Hine family permitted excavation of the site by halting quarry work.

The study of the Bacchus Marsh *Diprotodon* material was supported in part (B.M.) by an ARC Program Grant to Michael Archer; a grant from the Department of Arts, Sport, the Environment, Tourism and Territories to Michael Archer, Sue Hand and Henk Godthelp; a grant from the National Estate Program Grants Scheme to Michael Archer and Alan Bartholomai; and grants in aid to the Riversleigh Research Project from Wang Australia, ICI Australia and the Australian Geographic Society.

Excavation of the Bacchus Marsh *Diprotodon* material was financed by the Council of the Museum of Victoria. The preparation of this material was paid for by grants to Thomas H. Rich from ARC.

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A NEW FOSSIL WALLABY (MARSUPIALIA; MACROPODIDAE) FROM THE SOUTH EAST OF SOUTH AUSTRALIA.

J. A. McNAMARA

McNAMARA, J. A. 1994. A new fossil wallaby (Marsupialia; Macropodidae) from the South East of South Australia. *Rec. S. Aust. Mus.*: 27(2) 111–115.

A new wallaby, *Congruus congruus* gen. et sp. nov., is described, from a cave fill presumed to be of late Pleistocene age. While agreeing in some characters with many other macropodine genera, it most resembles *Prionotemnus* and *Protemnodon*.

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Manuscript received 17 June 1993.

Mammal faunas from the cave fills of the Naracoorte area have been reported by Williams (1980), Wells *et al.* (1984) and Pledge (1990). These caves have yielded big samples of medium to large macropods, but, so far, few new forms have been reported, notably *Sthenurus maddocki* (Wells and Murray 1979) and *Sthenurus* 'P17250' (Prideaux *et al.*, in press). Just as the highly distinctive but apparently rare vombatid *Warendja* is known from four specimens from only two localities, so it might be expected that, as collections grow and are examined critically, specimens of rarer forms will be discovered.

The unique type specimen was compared directly with all specimens available in the fossil and modern mammal collections of the South Australian Museum. It was prepared by hardening with dilute Bedacryl after it was decided that it was too delicate to be safely handled; nor could a patina of fine sand, cemented with lime, be removed without losing bone. The teeth of the left-hand side were hand cleaned.

Tooth numbers follow Archer (1978). The composition of the Macropodinae used is that of Flannery (1989) but without *Hadronomas* (Murray, 1991).

Fig.2 contains an orientation symbol consisting of an arrow pointing to the anterior and an upturned U representing the tongue or lingual side.

Systematics

Family MACROPODIDAE Gray 1821
subfamily MACROPODINAE Thomas, 1888

Congruus congruus gen. et sp. nov.

Holotype

P33475 (registered in the palaeontological collection of the South Australian Museum), a nearly complete adult skull with P^3, M^2, to M^5 both I^2 and left I^3, missing anterior part of left nasal, the right zygoma, part of right temporal and mastoid. The incisors show moderate wear. P^3 is unworn. The molars grade from the moderately worn M^2 to the unerupted M^5.

Locality

S.O.S. cave (5U132) just south of Naracoorte in the South East of South Australia.

Age

Late Pleistocene by faunal association.

Etymology

From the Latin for agreeable or harmonious. Gender masculine.

Diagnosis

Congruus agrees in many of its character states with other members of the Macropodinae, but more closely resembles *Protemnodon*, *Prionotemnus*, *Kurrabi*, *Wallabia* and *Macropus*. It can be distinguished from the other macropodine genera by many characters, including lack of canine, long diastema, higher-crowned molars, entire palate and size.

Congruus is distinguished from *Protemnodon* by possessing a deflected rostrum; a P^3 shorter than most molars (M^3, M^4, M^5); a rather small masseteric process, not extending down to the line of the alveolar margin; and by lacking a large labial groove on I^3.

It differs from *Prionotemnus* in possessing a more anterior placement of the infraorbital foramen; a less distinctly grooved P^3, with a wider

FIGURE 1. *Congruus congruus* holotype skull P33475, x 0.75.

TABLE 1. Measurements (mm) of skull of *Congruus congruus* (P33475, holotype).

Description	mm
maximum length sans teeth	160.0
maximum height	59.4
maximum width of frontals	50.3
maximum width of nasals	36.7
length of diastema between alveoli	39.9
palate width at mid-diastema	20.8
rostrum width at mid-diastema	22.6
maximum width of occiput	21.8
width of postorbital constriction	31.2
height of premaxilla	30.7

longitudinal basin; a P^3 shorter than M^5; higher-crowned molars with longer, more procumbent anterior cingula; a forelink on M^2 and M^3; and well-developed posthypocristae. It differs in lacking the deep groove well within the labial surface of I^3.

From *Kurrabi* it may be distinguished by its relatively short P^3; shorter, more anterior masseteric process; less elongate molars, having an oblique posthypocrista and lacking a distinct posterior fossette.

From *Wallabia*, *Congruus* is distinguished by its lacking a prominent labial groove on I^3; well developed labial crests on all molars; and an anterior nasal spine. It is further distinguished by possessing procumbent incisors, an entire palate, a P^3 shorter relative to the molars, with a smooth longitudinal basin; and by having the anterior portion of the brain case less constricted.

It differs from *Macropus* in lacking the distinct anterior (postorbital) constriction of the brain case; a groove on the labial surface of I^3; a developed posterior fossette on the molars; and the inflation of the nasal part of the rostrum, relative to the anterior palate. *Congruus* is distinguished from *Macropus* by possession of more procumbent incisors; an entire palate; a well-developed ovale crest; oblique posthypocristae; and in having the loph-crests less bowed or preparacristae less developed.

Description

The skull, in general aspect, is lightly built, with a relatively large brain case, comparing in its gracility, with many living *Macropus* species.

From the side the skull presents a generally flat dorsal profile. The incisors and premaxillae are procumbent. No anterior nasal spine is present but in this position the premaxillae are smooth and depressed. The deep rostrum is arched dorsally and is near the plane of the flattened, somewhat depressed frontal bones and the slightly raised frontoparietal region. The parietals decline towards a slight lambdoidal crest. A large diastema reveals a palate declining from a rather level cheek tooth row. The infraorbital foramen is above the anterior half of P^3. The orbit appears relatively small and the zygomatic arch, light and shallow. The masseteric process is opposite the protoloph of M^4, and small, not reaching the level of the alveolar margin.

From above, the rostrum tapers evenly forward from the lacrimals, and is flat sided without lateral inflation of the nasal part. The nasals have a broad, fairly straight contact with the frontals, on a line with the lacrimal foramina. The frontal bones are broad and flat, inflated laterally, above the orbit, and slightly depressed, centrally, on their common suture. The anterior part of the brain case is not greatly constricted postorbitally as it is in many macropodine genera. There is no sagittal crest and the temporal foramen is small.

From below, the incisive foramina are small. There are no canines. The palate, anterior to the cheek teeth, nearly equals the width of the rostrum above. The palate appears to have been entire. Pterygoid cavities, appearing small, have their lateral borders formed by prominent anterior-directed ovale crests. The alisphenoid bulla is slightly inflated and the auditory process is short.

Teeth.

I^1 is unknown but the alveolus is slightly larger than that of I^2, rounded, narrowed ventrally and not much compressed laterally.

I^2 shows no sign of an occlusal groove, perhaps, due to wear. The corresponding structure on I^3 is attenuated and may indicate that the groove was much reduced or lacking on I^2. A broad shallow groove runs parallel and just anterior to the posterolabial edge, of I^2, which is raised and ridge-like.

I^3 has a narrow and shallow occlusal groove

TABLE 2. Measurements (mm) of upper cheek teeth of *Congruus congruus* (P33475, holotype)

	Length	Anterior width	Posterior width
P^3	9.8	4.6	5.0
M^2	8.6	6.9	7.1
M^3	10.6	8.1	7.8
M^4	11.5	8.6	8.2
M^4 (estimated)	10.4	8.9	8.0
$P^3 - M^4$	37.7	–	–
$P^3 - M^5$ (estimated)	48.1	–	–

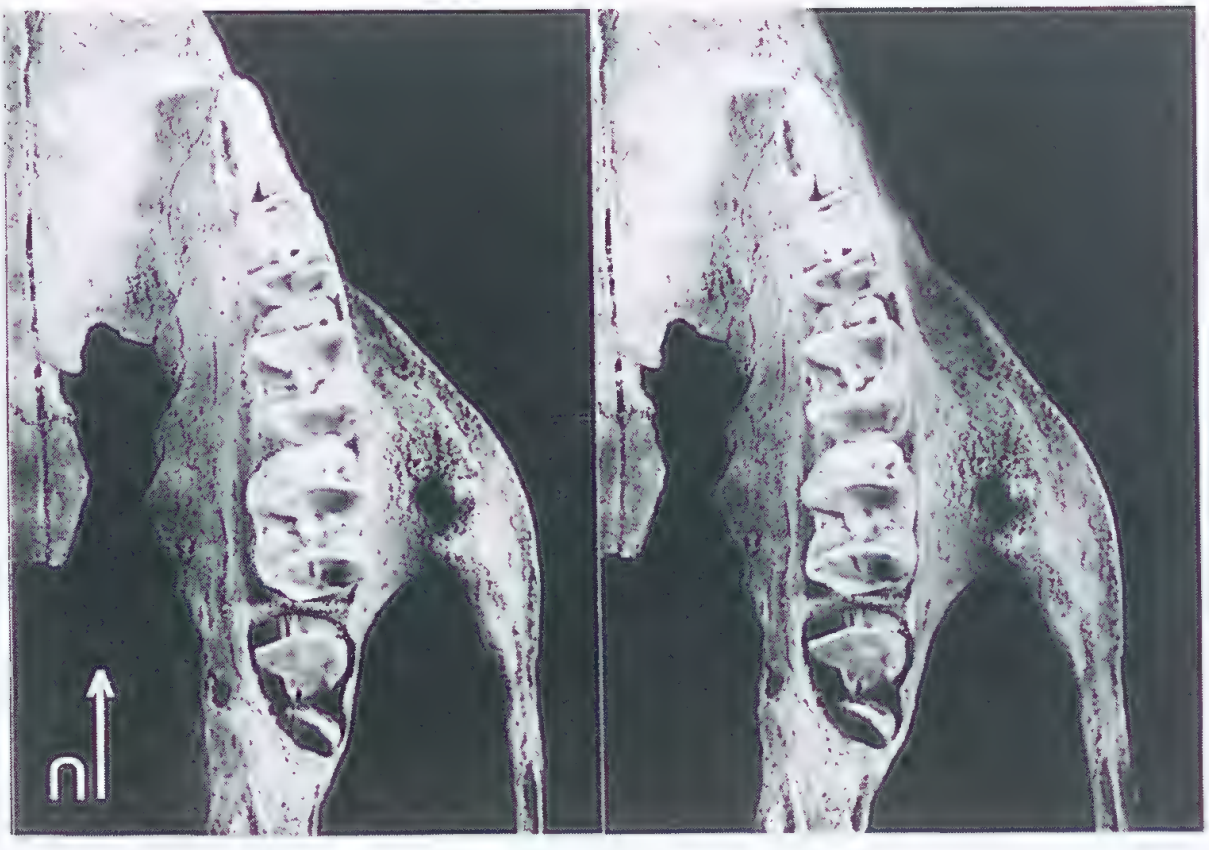

FIGURE 2. *Congruus congruus* holotype P33475, stereopair of left cheek teeth, x 1.5.

which opens near the posterior edge of the labial surface so that the small lingual crest is barely visible and the groove so formed is barely visible on the labial surface. I have interpreted a pit, midway along the posterolabial edge of this tooth, as pathological but of localised effect and not associated with any general distortion of the crown – a view supported by the alveolus of the right I^3 which indicates a very similar tooth. It is probable that all the incisors were high crowned, and that, their relative sizes were $I^1 > I^2 > I^3$. Their combined outline in occlusal view was probably U-shaped.

P^3 is a little longer than M^2. Its outline is not concave labially. There is a prominent labial crest with anterior and posterior cusps, with three indistinct cuspules and ridgelets between. There is a prominent posterolingual cusp, lower than the posterior cusp, and connected to it by a ridge, behind which is a small shallow posterior fossette. From the posterolingual cusp, a lingual cingulum runs forward, and is notched at one third of the tooth length, then is somewhat raised, before ending, almost opposite the anterior cusp. This cingulum, together with the main crest, forms a smooth longitudinal basin.

The upper molars are plain and quadrate, becoming more elongate and increasing in length from M^2 to M^4 and probably M^5. The anterior cingulum is broad and shelflike with a shallow basin between it and the protoloph to which it is connected by a preparacrista. A low forelink is present on M^2 and M^3 but not visible on M^4 or M^5. The width and length of the anterior cingulum increases from M^2 to M^5. The anterior width of M^2 is less than its posterior width but near equal in the other molars. The lophs have their apical width nearly equal to the basal width, not markedly narrower as in many *Macropus* and *Kurrabi*. A midlink is formed just lingual to the middle of the transverse valley by the postprotocrista, there is a small contribution from the metaloph. A shallow basin is formed in the transverse valley by an extension of the postparacrista on M^2 and M^3, but not, M^4 and M^5. The posterior face of the metaloph is rather plain and flattened, with a distinct posthypocrista rising obliquely to join the base of the metacone, where a small groove separates it from a much less distinct, near vertical, postmetacrista. Together they do not form a centrally placed fossette, seen in many forms, including *Macropus*, *Protemonodon*, *Thylogale*, *Wallabia* and *Onychogalea*. A much reduced postlink is discernible on M^4.

Discussion

The age of this material is inferred from its

association with *Thylacinus* and *Sthenurus* P17250 material with very similar preservation. This *Sthenurus* is known from the dated deposits of Victoria Cave (Wells *et al.* 1984) and the Henschke Fossil Cave (Pledge 1990), Naracoorte, and Green Waterhole (Newton 1988), Tantanoola.

Discovery of further specimens, particularly those with the lower dentition and deciduous cheek teeth, should add to the understanding of this form and, in particular, clarify its relationship to *Prionotemnus*.

One's attention is drawn to the prominent naso-frontal development of this species, which is presumably an autapomorphic character. Comparisons can be made with the similar structures found in *Onychogalea unguifera* and, if its function were known, it would allow conclusions about the functional adaptation of the fossil form.

In *Congruus* a combination of many primitive macropodine features seem to be the foundation, overlain by apomorphy in the form of the whole skull giving it the general aspect of a modern-looking kangaroo. While this is adding to the increasingly large puzzle that is macropod phylogenetics, it is to be hoped that future study of this specimen will shed light on the major pathways followed by this family in its great evolutionary flowering through the latter half of the Neogene to the present.

Acknowledgments

I wish to thank Mr A. D. (Tony) Colhoun for recovering the material and lodging it with the South Australian Museum. Thanks are also due to: N. S. Pledge, and G. Prideaux, for reading a draft of this paper; D. Van Weenen, for typing; and T. Peters for photography.

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CETACEAN FOSSILS FROM THE LOWER OLIGOCENE OF SOUTH AUSTRALIA

NEVILLE S. PLEDGE

PLEDGE, N. S. 1994. Cetacean fossils from the Lower Oligocene of South Australia. *Rec. S. Aust. Mus.* **27**(2): 117–123.

A single, damaged cetacean tooth from the upper part of the Buccleuch Formation of the Murray Basin dates from the early Oligocene. It has been compared with Eocene archaeocetes and with late Oligocene cetaceans. Similarities are seen with *Mammalodon colliveri* and *Metasqualodon harwoodii*, but no definite assignment can be made.

A limb bone from rocks of similar age in the St Vincent Basin is described briefly, but cannot be ascribed definitely to any particular cetacean group.

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Despite its vast areas and extensive sequence of Tertiary sediments (e.g. Ludbrook 1969), South Australia seems to be remarkably deficient in cetacean fossils. Most of these, usually just single or a few associated bones of cetaceans, have been found in lower Miocene sediments exposed in cliffs along the lower part of the River Murray. Discoveries are summarised in Glaessner (1955), Pledge and Rothausen (1977), Fordyce (1982, 1984) and Bearlin (1988).

One of these whales, *Metasqualodon harwoodii* (Sanger 1881), was found in the Wellington area of the River Murray, but its exact site, and consequently its precise stratigraphic horizon, was not recorded and has been the subject of some speculation (Pledge & Rothausen 1977). It was therefore with some excitement that the author received a primitive-looking cetacean tooth found by amateur palaeontologist and collector Mr D. J. Barrie in February 1989 at Fred's Landing, a few kilometres upstream from Wellington (Fig. 1). Closer examination, however, has shown the tooth not to be *Metasqualodon harwoodii*, but an older, possibly new taxon. Further excavation at the site failed to yield more cetacean specimens, but resulted in a rich, previously unknown, foraminiferal assemblage being recovered (Lablack, pers. comm. 19/2/91, 1991 unpublished report).

The specimens are registered with the South Australian Museum, Palaeontology Collections (SAM P). MUGD refers to specimens in the Geology Department of the University of Melbourne.

SYSTEMATICS

Class Mammalia

Order Cetacea Brisson 1762

Suborder *incertae sedis*

Genus and species indeterminate, A

Material:

The damaged crown of an anterior cheek tooth, SAM P34517.

Locality:

Fred's Landing, a boat launching area 3 km downstream from Tailem Bend, on the east bank of the River Murray. (Lat. 35°17'S, Long. 139°27'E).

Geology and Age:

The fossiliferous beds have a very restricted outcrop, but have since been recognised more widely in subsurface sections to the southeast.

The pale green, limonite-stained and slightly glauconitic, marly fine-grained limestone has a rich planktonic foraminiferal fauna, with key species *Guembelitria triseriata* and *Chiloguembelina cubensis* and associated species *Sherbonina atkinsoni*, *Gyroidinoides* sp. cf. *G. allani*, *Bolivinopsis cubensis*, *Globigerina ciperoensis* and *Globigerina ouchitatensis* (Lablack 1991).

There is an invertebrate megafauna dominated

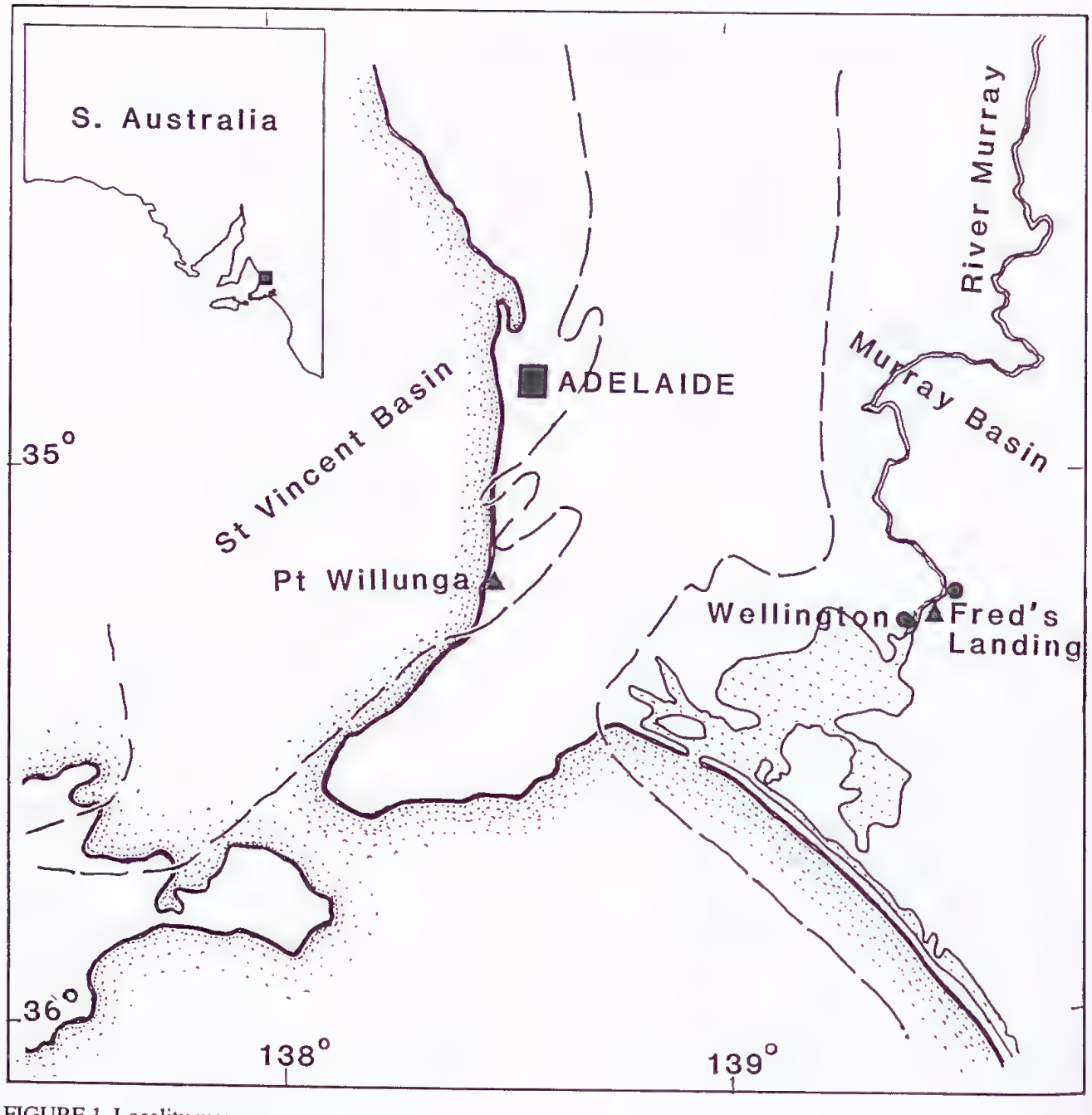

FIGURE 1. Locality map

by the small brachiopod *Murravia catenuliformis* and a small morph of the echinoid *Scutellinoides* sp. cf. *S. patella*, with occasional *Waldheimia* sp. cf. *W. insolita* and *Magasella woodsiana* (brachiopods) and *Corystus dysasteroides* (echinoid) fragments, *Graphularia* segments, small scallops (*Chlamys*), bryozoans and asteroid ossicles. There are also rare small shark teeth (*Lamna* sp. cf. *L. apiculata* and *Scapanorhynchus maslinensis*), and a broken teleost otolith. Unfortunately, none of these species is age specific, although *S. maslinensis* is found mostly in late Eocene formations (Pledge 1967).

Lithologically, the beds are similar to the Ettrick Formation (middle to upper Oligocene) which occurs nearby. However, on the basis of the foraminiferal fauna, particularly *G. triseriata*, Lablack (1991 and pers. comm.) equated the unit in question with the lower part (Ruwarang to Aldinga members) of the Port Willunga Formation of the St Vincent Basin.

The planktonic foraminifera are more abundant in the Fred's Landing section than in the Port Willunga local type section for the South Australian lower Oligocene, where the sudden appearance of the key species *Guembelitria triseriata* (which has a restricted stratigraphic range in South Australia) marks the maximum flooding surface T4.4 of the major transgressive phase following the terminal Eocene regression

(McGowran *et al.* 1992). The presence of *G. triseriata* and *Chiloguembelina cubensis* together restricts the age to the early Oligocene (e.g. Moss and McGowran 1993), and the beds to the upper part of the Buccleuch Formation of the Murray Basin.

Description:

Orientation of the tooth is on the basis of comparison with cheek teeth of *Dorudon* spp., particularly *D. stromeri*, and *Zygorhiza kochii* (see Kellogg 1936) where the anterior edges of asymmetrical teeth tend to be shorter and closer to vertical, and basal cingula are developed on the lingual faces. Insofar as that in *Zygorhiza kochii* only the upper cheek teeth have internal cingula, the Fred's Landing tooth may be considered to be an upper right anterior cheek tooth. However, cingula are too variable in cetaceans to be reliable characters and Fordyce (pers. comm. 19/8/91) has suggested, on the basis of its lack of lingual or posterior recurvature, that the tooth might be a lower left anterior cheek tooth, possibly equivalent to P_2 or P_3. (Fig. 2)

The tooth is not large: its preserved basal length is 16.3 mm, anterior width 8.2 mm, crown height (measured lingually) >16 mm. It is thus slightly larger than the figured tooth (MUGD 1874) of

FIGURE 2. Whale tooth SAM P34517, stereopairs in: **a**, putative lingual **b**, labial and **c**, occlusal views. Scale in millimetres.

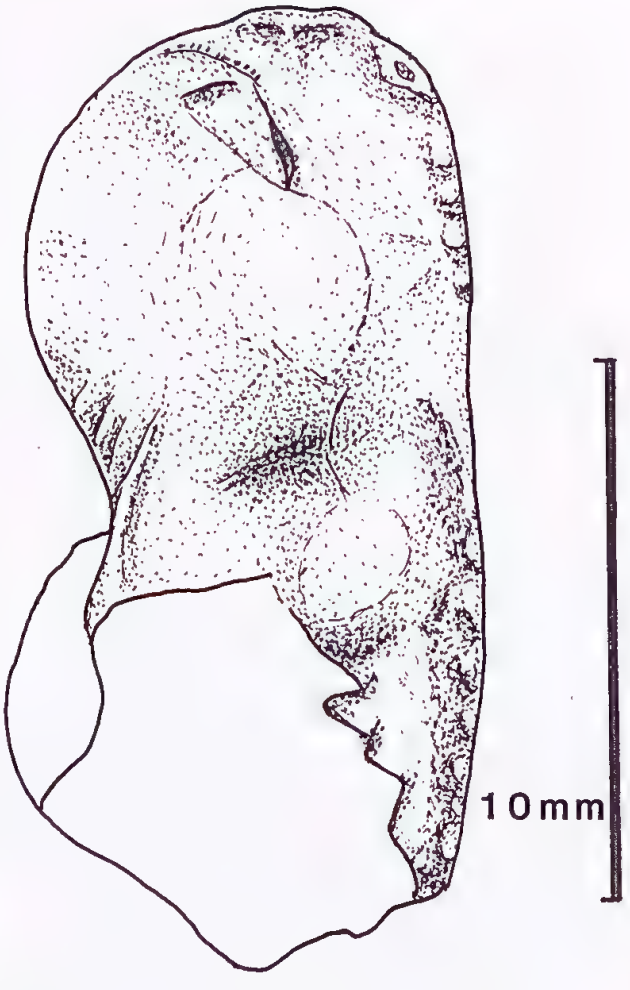

FIGURE 3. Detail of occlusal view. SAM P34517.

Mammalodon colliveri (Pritchard 1939). It is also quite high-crowned for its size when compared with other early taxa.

The tooth is damaged posteriorly, probably during life since the enamel edge is rounded and the exposed dentine polished by tooth-on-tooth wear. This has removed the distal cutting edge and all but the uppermost denticle. All denticles show occlusal wear.

The base of the crown rises sharply to its midpoint, corresponding to the indented groove that marks the union of the two roots. (The possibly divided distal end is not preserved.) The apex of the tooth is just anterior to this and is an acute cusp, slightly more convex labially. The anterior edge (carina) descends abruptly forwards to a small denticle about 9 mm above the anterior base of the enamel and continues slightly lingually to a smaller basal denticle (Fig. 3). From here a lingual cingulum curves posteriorly, parallel to the base of the crown, and bears a series of five tiny tubercles which gradually diminish towards the midpoint of the tooth. The tubercles reappear on the posterior half of the cingulum and number at

least six. The cingulum is not continuous across the midpoint of the face. The lingual face of the crown also bears a series of rather coarse, somewhat anastomosing ridges or wrinkles (cristae rugosae) in the enamel of the lower part — only the medial one crosses the cingulum onto the basal zone. The labial face has a slightly greater number of slightly finer ridges which extend higher and lower (to within 2 mm of the base) than on the lingual face. There is no obvious labial (external) cingulum. Of the posterior carina, only the upper-most secondary denticle is preserved (it is about one-third the size of the main cusp) together with the sharp crest joining it to the apex.

Discussion:

The antiquity of this specimen, Early Oligocene, makes it quite significant, since this is when it is considered (e.g. Barnes & Mitchell 1978, Fordyce 1984, 1989) that mysticetes arose from the archaeocetes. Indeed, there are few cetacean specimens recorded of this age and these are listed by Fordyce (1992). Because of its locality, the tooth was initially compared to *Metasqualodon harwoodii* (specimen P8446.4) (Fig. 4b) but that species, although of similar size, lacks any indication of the cingular cusps, and it has a greater cristae density (Pledge & Rothausen 1971). Preservation is also strikingly different, the *Metasqualodon* teeth being black and the new tooth creamy yellow in basic colour, suggesting a different lithologic provenance, and hence formation and age.

The Fred's Landing tooth has been compared with descriptions and figures of those of archaeocetes, particularly species of *Dorudon* (Kellogg 1936, Fordyce 1985), which are much larger than the new specimen. Closest similarity in presumed overall form is seen in *D. stromeri*, e.g. M_2 in Pl. 26 (3h) (Kellogg 1936) and *D. osiris* P^2 in Pl. 22 (2) (*idem.*). The latter figure shows the teeth in good detail, to indicate that the external face sometimes has a basal cingulum, but in any case does not have cingular tubercles. The greatest similarity of the cingulum and its tubercles is seen in *Zygorhiza kochii*, P^2 in Pl. 12 (1a) (*idem.*).

There are some similarities with the incomplete premolar tooth from Waihao, New Zealand, referred by Fordyce (1985) to the Dorudontinae. This tooth (ZMT79) is considered to be a second premolar; unfortunately it is broken above the base of the enamel, so it cannot be determined whether a basal cingulum was present. The surface ornamentation of coarse, irregular cristae on the lingual face and somewhat finer ones on the labial face, together with its overall shape of a steep anterior edge (possibly with a basal denticle) and a posterior edge with at least two large denticles bears a similarity with the new South Australian specimen, which differs most noticeably in its smaller size and lower cristae density.

Comparison with other published cetacean taxa of similar early Oligocene age has proved negative. There is little or no similarity with the possible mysticete from the lower Oligocene of Waikari, North Canterbury, New Zealand (Fordyce 1989), nor with Keyes' (1973) early Oligocene 'proto-squalodontid' from Oamaru, or Mitchell's (1989) *Llanocetus denticrenatus* from the late Eocene/early Oligocene of Seymour Island, Antarctic Peninsula. The later Oligocene cetaceans *Phococetus vasconum* from France, *Platyosphys paulsonii* from the Ukraine, *Sulakocetus dagestanicus* from Caucasus, *Kelloggia barbarus* from Azerbaidzhan, *Aetiocetus cotylaveus* from Oregon, *Squalodon ?serratus* from New Zealand and *'S'. gambierensis* from South Australia (Emlong 1966, Glaessner 1955, 1972, Mchedlidze 1984) likewise provide no insight into the identity of the Fred's Landing cetacean. This leaves *Metasqualodon* and *Mammalodon* to be considered.

Metasqualodon harwoodii differs slightly from the Fred's Landing tooth (which seems morphologically intermediate between SAM P8446.1 and P8446.4) in being more symmetrical about the main cusp, having finer and more numerous cristae in the enamel, a much less distinct cingulum, and fewer and much smaller tubercles restricted towards the extremities of the cingulum (rather than absent only from the central few millimetres). Fordyce (pers. comm. 19/8/91) doubts that *Metasqualodon* is a squalodontid, and asks if it might not be a mysticete like *Mammalodon*.

FIGURE 4. Near-contemporary Australian cetacean teeth: a, *Mammalodon colliveri* MUGD1874, b, *Metasqualodon harwoodii* SAM P8446.4 labial (?) views, scale in millimetres.

Comparison with *Mammalodon colliveri* (Pritchard 1939) is frustrating, because of the extremely worn nature of those teeth (Fordyce 1984, Mitchell 1989) (Fig. 4a). However, the isolated tooth MUGD 1874 does show 3–4 small cusps on that part of the lingual cingulum still preserved. That species differs from the Fred's Landing tooth in having more numerous ridges on the labial face of the tooth but the significance of this is unknown. The extreme degree of occlusal wear of the teeth, all in the same plane, is a distinctive feature, which Mitchell (1989) suggested might be related to a particular feeding strategy. In the Fred's Landing tooth, the main cusp is beginning to show signs of wear. Such a character does not seem to occur in the putative squalodontids *Prosqualodon davidis* or *Metasqualodon harwoodii*, although some squalondontids may show it. Fordyce (1982) has compared the skull of *Mammalodon* to that of *Dorudon* spp. and primitive mysticetes, concluding that while there are similarities with the dorudontines, *Mammalodon* is probably a very primitive mysticete. It occupies a morphologically intermediate position but is too recent to have been the ancestor of mysticetes since it is contemporaneous with early cetotheres (Fordyce 1984). *Mammalodon colliveri* is believed to be of latest Oligocene age.

On balance, the greatest similarities of the Fred's Landing tooth seem to be with *Mammalodon colliveri*, yet a case might be made that, on the few characters preserved in these species, it is morphologically intermediate between *Mammalodon* and *Metasqualodon*. The tooth cannot, therefore, be assigned to either taxon, or indeed to any particular suborder on the material and evidence available.

Genus and species indeterminate, B.

Material:

A right radius, SAM P10875.

Locality:

Cliffs between Port Willunga and Aldinga Bay, South Australia (Fig. 1). Collected by Mr Mark Hagman, 1954.

Age:

It is unfortunate that the locality was not recorded more precisely, since this stretch of coast line encompasses the earliest Oligocene beds (Lindsay 1967, 1985; Lindsay & McGowran 1986) within the Port Willunga Formation. The low dip of the beds (about 3° to the south) means that the bone could be of almost any age within this period. However, it had been thoroughly cleaned and there remained no trace of matrix that might have been used for micropalaeontological examination. On the other hand, the thoroughness of the cleaning suggests the bone came from a sandy or clayey horizon of either the Aldinga or Ruwarang Members of the Port Willunga Formation.

Description:

The bone, kindly identified by R. E. Fordyce (4 February 1981) is a right radius lacking the distal epiphysis (Fig. 5). It is damaged along the whole of the posterior edge, possibly by crushing. The

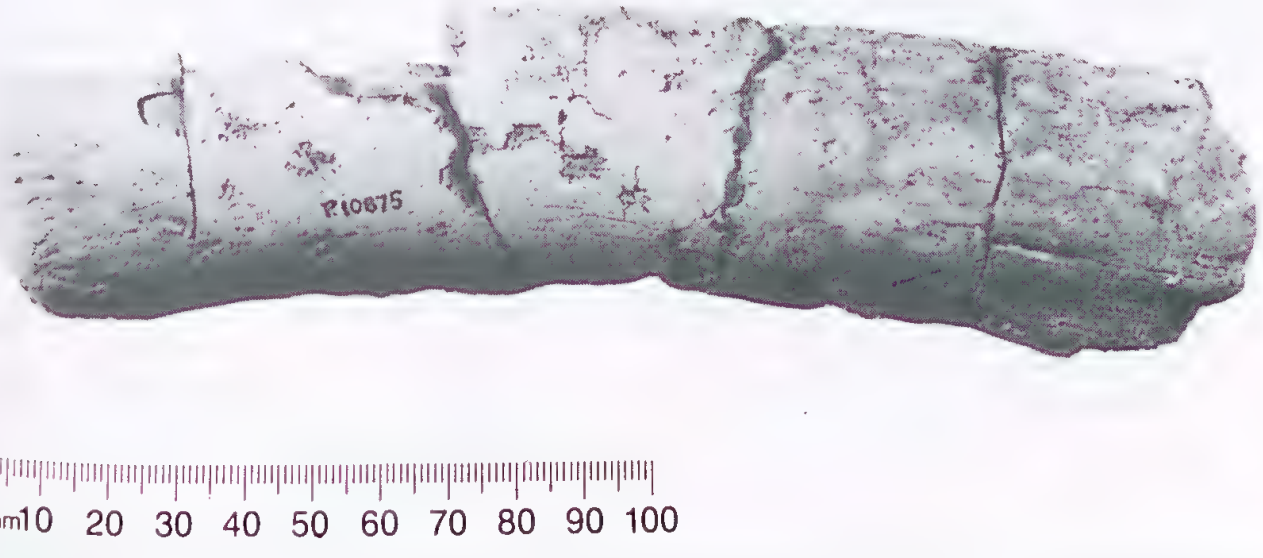

FIGURE 5. Cetacean right radius SAM P10875 from Port Willunga Formation, Aldinga Bay, in lateral aspect. Scale in millimetres.

shaft is slightly curved, convex anteriorly, and more convex on its outer surface. The prominent anterior angle seen in archaeocetes (e.g. Kellogg 1936) has been broken off and only its roots remain. The inner surface of the shaft is almost flat at its midpoint. At the proximal end, the articular surface is ovate to rectangular in outline and slightly concave but is damaged posteriorly, while the distal end of the bone is lenticular in cross-section. The length is 190 mm overall with a midpoint thickness of 22 mm and diameter of more than 42 mm. The proximal end measures 34 mm by an estimated 40 mm while the distal end is approximately 27 x 45 mm.

A diagonal line of punctures can be seen midway along the outer surface of the radius, and can be traced in a tight arc towards the proximal end and back to the posterior edge. These punctures are interpreted as tooth marks, possibly from a small shark, that were inflicted before burial, perhaps even before death, with the attack on the right paddle coming from behind.

Discussion:

The bone shows the pachyostosis typical of *Basilosaurus* (Kellogg 1936) and sirenians. It is straighter and much smaller than the tibia of *Basilosaurus cetoides* (*ibid.*) but resembles it more than it does *Zygorhiza kochii* or *Dorudon* spp., which it slightly exceeds in size. Apart from this only slight curvature of the shaft, the Aldinga bone differs markedly from all these species in the lesser development of the anterior angle. Conversely, its curvature and development of the anterior angle is greater than that seen in some Miocene cetotheres. It is unfortunate that the radius is not preserved in the still-undescribed *Mammalodon* skeleton (Fordyce, pers. comm. 19/8/91), but that would be unlikely to be of great help since the early odontocetes and mysticetes also have archaeocete-like forelimbs (*ibid.*).

Conclusions

The early Oligocene is seen to be a crucial time in cetacean evolution (e.g. Fordyce 1991, 1992). Despite it being almost impossible to establish its phylogenetic position, it is possible that the Fred's Landing tooth represents, if only morphologically, an intermediate stage between the Eocene (dorudont) archaeocetes and the succeeding mysticetes and odontocetes.

The Eocene/Oligocene boundary period is also important palaeogeographically and palaeoclimatologically, with the establishment of the Circum-Antarctic Current (e.g. McGowran *et al.* 1992; Moss & McGowran 1993; Kennett *et al.* 1975; Fordyce 1977, 1989b, 1992) in the early Oligocene. Fordyce (1992) has linked the start of the radiation of modern cetaceans with this event and its concomitant global cooling and opening of new feeding niches and strategies. The richness and abundance of the planktonic foraminiferal fauna of the Fred's Landing beds suggests a relatively open marine environment (Lablack 1991) which is in agreement with this scenario.

The two specimens reported here, albeit taxonomically and phylogenetically indeterminate, offer the possibility that critical specimens for elucidating the origins of modern whales may eventually be found in this part of the world.

Acknowledgments

I thank John Barrie for donating this specimen to the South Australian Museum, Karen Lablack and Brian McGowran for advice on foraminiferal biostratigraphy and Ben McHenry for brachiopod identifications. Ewan Fordyce made valuable comments on an early draft of the paper but the interpretations are mine. Debbie Churches typed the manuscript and Jenni Thurmer advised on the figures.

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LATE QUATERNARY CHANGES IN THE MOA FAUNA (AVES; DINORNITHIFORMES) ON THE WEST COAST OF THE SOUTH ISLAND, NEW ZEALAND.

T. H. WORTHY

WORTHY, T. H. 1994. Late Quaternary changes in the moa fauna (Aves; Dinornithiformes) on the West Coast of the South Island, New Zealand. *Rec. S. Aust. Mus.* **27**(2): 125–134.

The fossil moa faunas from caves on the New Zealand West Coast between Westport and Greymouth are described with particular reference to Madonna Cave. Site stratigraphy and radiocarbon dating of moa bone collagen allow dating of associated faunas. Eight moa species are recorded with a total of 220 individuals. Two distinct moa faunas are recognised: 1. a glacial fauna (10 000 – 25 000 radiocarbon years) consisting of *Pachyornis elephantopus*, *Euryapteryx geranoides*, and a large morph of *Megalapteryx didinus*. 2. a Holocene fauna (0 to 10 000 radiocarbon years) consisting of *Anomalopteryx didiformis* (most common), a small morph of *Megalapteryx didinus*, *Dinornis novaezealandiae*, and *D. struthoides*. Two species, *D. giganteus* and *Pachyornis australis*, were very rare and are not typical components of either fauna in this area.

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Discrete species assemblages of moas associated with specific palaeoenvironments were recognised by Anderson (1989) and Worthy (1990, 1993a). Correlated with environmental change from the Otira Glacial to the Holocene, changes in the species composition of both moa and non-moa faunas were described by Worthy & Mildenhall (1989) and Worthy (1993a), from fossil deposits in Honeycomb Hill Cave, Oparara Valley, Northwest Nelson. It is reasonable to expect that such changes would have parallels in all areas of New Zealand where significant vegetation changes occurred between glacial and interglacial conditions.

In many continental areas palaeobiogeography of mammals has been used to infer climate, for example late Pleistocene changes in Australia (Lundelius 1983), but only recently has the use of birds been advocated (Baird 1989). Baird argues that birds are better suited for palaeo-environmental reconstructions because they are well represented in the fossil record, can be identified to species level often, and identification of niche in modern analogues is easier. Baird (1991) considered the fossil bird assemblages in several sites to be indicative of past environmental conditions, and with radiocarbon dating, documented environmental change through the late Pleistocene that was consistent with patterns obtained by other means.

New Zealand has a large body of data which indicates it had a similar pattern of vegetation change to Australia. These vegetation changes are correlated with climatic changes during the interglacial – glacial cycles (McGlone 1985, 1988). As the fossil record within New Zealand caves is only known to extend from the Otira (last) Glaciation to the present, this is the period considered here. Palynological studies show that the majority of sites in the South Island were dominated by grassland and shrubland taxa, with trees less than 10% of total taxa indicating that forest was sparsely present, if at all, in many regions during the glacial maximum (22 000 – 14 000 years ago) (McGlone 1988). The climate then was characterised by temperatures about 5 °C cooler and by being considerably drier, a combination which effectively excluded forests. During the late glacial (14 000 – 10 000 years ago) pollen evidence suggests rapid afforestation occurred in many areas, at slightly different times depending on local conditions. For example, around Wellington reafforestation was much later than elsewhere (Lewis and Mildenhall 1985), perhaps a corollary of the present frequent exposure to southerly winds there now. In many South Island areas the late glacial saw grasslands give way to shrublands and tall scrublands. These changes were correlated with increased temperatures and increased precipitation. At the commencement of the Holocene (10 000 years ago) a return to present day temperatures and precipitation similar to that now resulted in rapid widespread vegetation change with tall podocarp forests becoming dominant in most lowland areas (McGlone 1988).

New Zealand cave fossil deposits, unlike most swamp and all dune deposits, range in age from the Otira Glacial to the present so, alone, have potential for demonstrating faunal changes correlated with the above described vegetation changes. Demonstration of these faunal changes is conditional on investigation design. If a cave is considered to be the 'site' and all fossils indiscriminately associated together, or all faunas from caves within a region considered as one, then by investigation design, perception of temporal changes is ruled out. Dating is necessary to determine the time span of deposition for each discrete site in a cave. In this regard isolated skeletons, or bones in surface deposits within a cave, should be considered as discrete events which need to be individually dated, unless on the basis of sedimentary history within the cave, or similar speleogenetic evidence, an upper age limit can be set on fossil deposition.

The following example illustrates how study design compromises resultant conclusions. Atkinson & Millener (1991) analysed the cave fossil fauna around Waitomo in the North Island using data compiled from sites in 156 separate caves (Millener 1981), not 37 as they stated. Insufficient attention was paid to the age of the fossils. Most were collected by amateurs from surface deposits that could have been up to 100 000 years old (speleothems of this age are known in some Waitomo caves (Hendy 1969)). Younger fossils were more likely to have been more abundant for two reasons. Firstly, younger fossils would have been subject to destructive processes for a shorter period of time, and secondly in many cases younger sediments overlie and therefore obscure older material. No attempt was made by these authors to justify temporal association of fossils from individual sites within caves – caves were treated as sites – nor was temporal association of deposits from separate caves proven, beyond the observation that dates for fossils from 10 caves ranged from one to twenty five thousand years old. Despite the proven age of the fossil deposits spanning two major climate regimes, all species in the faunal list were assumed to have been present contemporaneously between 6 000 and 1 000 years BP. To treat all fossils as a unit necessarily obscured any patterns there may have been and so, as younger fossils predominated, Atkinson and Millener's approach resulted in the conclusion: 'A humid lowland forest thus dominated the area throughout the period when faunal remains were accumulating'. This is a description of the environment that prevailed in the area during the Holocene, and describes conditions that must have differed from those prevailing during the glacial period, if the palaeotemperature curve for the region is any indication (Hendy 1969).

Apart from age, the limitations imposed by taphonomic processes (Baird 1991), especially as they apply to species representation, need to be understood and assessed before sites are compared. With increased water flow at a site there is progressive removal and destruction from smaller to larger fossils resulting in a marked bias towards preservation of moa bones in stream sediments. The New Zealand birds observed to be specific indicator species of open-country habitat, for example the pipit and New Zealand quail, have small bones for which suitable preservation conditions are rarely encountered in New Zealand caves. Their absence or rarity in the Waitomo fauna as a whole (as so far described) does not preclude their having been common in the area during the Otiran.

The present study arose out of a survey of the Quaternary fossil bird fauna of the Punakaiki karst region, West Coast, South Island (Worthy & Holdaway 1993). Preliminary examination of the Canterbury Museum's collection of fossils from the region indicated that elements of both the *Anomalopteryx* and *Euryapteryx* assemblages of

FIGURE 1. Locality map showing the study area in New Zealand.

Anderson (1989) occurred in apparent geographic sympatry which would have been inconsistent with observations made by Worthy (1990). Further north at Honeycomb Hill Cave on the West Coast recent research has shown that moa assemblages changed with climate from the Otiran to the Holocene (Worthy & Mildenhall 1989; Worthy 1993a). I therefore thought it probable that the fossil deposits of the Punakaiki area also preserved elements of at least two successive and distinct moa faunas.

During the survey of caves in the Punakaiki area a site was searched for in which to test the hypothesis of moa faunal turn-over. I chose Madonna Cave because it contained several closely associated sites, each with stratigraphic control, and large numbers of fossils. The initial examination of the cave revealed a number of rich and discrete fossil sites representing a range of depositional environments. Some were in fluvial stratified sediments, and others under entrances. Different species assemblages were noted in different sites. In addition, it was noted that discrete periods of sedimentation had incorporated fossils in stratified sediments that were therefore likely to provide dates reliable for building a chronology of change in moa species. Later erosion had re-excavated most of these sediments leaving only remnant banks, and because these fluvial sediments had also been deposited and eroded from passages beneath entrance shafts, the fossil deposits under the shafts must have accumulated subsequent to the erosion. Therefore, data from these various sites could be used, in combination, to test the hypothesis.

Madonna Cave is between Waggon Creek and Doubtful Creek on the south side of the Tiropahi (Four Mile) River, between Westport and Greymouth (Fig. 1). The approximate grid reference for the centre of the cave system, on the metric 1: 50 000 map series NZMS 260, is K30 819127. The cave system drains a karst area, about 200 m above sea level, that has many dolines and natural traps in the form of shafts and grikes. The area is vegetated in mature mixed beech/podocarp forest with emergent rata trees up to 35 m in height. The forest floor and tree trunks are cloaked in deep moss that is indicative of the regular high rainfall (c. 3 000mm).

The cave system comprises three sections: Equinox Cave about 250 m long; and the 'upper levels' and the 'lower levels' of Madonna Cave which together have 1 436 m of surveyed passages in them. The cave is characterised by numerous entrances (see Fig. 2). In each area of the cave small streams now flow in the lowest levels but it is in the older stream courses at higher levels that sedimentary deposits are preserved. These sediments vary from sands to coarse gravel and moa fossils are visible in some. Abundant moa fossils also occurred in the streambeds.

Definitions

Allochthonous versus autochthonous. Fossils in caves have been classified as allochthonous (died at a different place to that in which the fossils are deposited), or autochthonous (where the fossils are found at or near where the animals died) by Baird (1991). In the surface environment such an assessment of fossil sites prior to palaeoenvironmental reconstruction is extremely important as fossils in fluvial deposition sites could have their origin many miles away, and therefore could have been transported out of the environment they lived in. Assessing cave sites in this fashion would result in fossils from stream sediments being classed as allochthonous. However, I contend that to discount use of data from these sources for palaeoenvironmental reconstruction, as is necessary for surface sites, would omit relevant data. This view is held as in the majority of caves, and especially within Madonna Cave, all fossiliferous fluvial sediments can be easily traced to their point of origin that is at most only a few hundred metres distant. So all bird fossils in such cave sediments can be considered autochthonous with respect to the home range of the living bird, and can justifiably be used in palaeoenvironmental reconstructions. I therefore use the terms 'allochthonous deposits' and 'autochthonous deposits' to indicate only that bones have, or have not, been secondarily transported from the point of death. I use the term 'autochthonous assemblage' to indicate that it is an assemblage of local derivation, which may be in either of the above deposit types.

MNI is minimum number of individuals determined from the number of the most abundant ipsolateral element.

Radiocarbon dating was done by the Institute of Geological and Nuclear Sciences Ltd laboratories at Lower Hutt, New Zealand, on the collagen fraction of bones, and ages are given as 'conventional radiocarbon age', where Libby T½ = 5568 yrs BP.

MNZ is the Museum of New Zealand Te Papa Tongarewa (was the National Museum of NZ) Wellington.

Results

Fossil Deposits

The fossil sites located within Madonna Cave are shown on Figure 2. There were three main types of fossil deposits in the cave: 1. Allochthonous deposits of scattered water-transported fossils that were not enclosed in sediments (sites 1–9,14,15); 2. Allochthonous deposits of fossils that were in fluvial sediments (sites 11,11a,13,16); 3. Fossils that had accumulated in autochthonous deposits below entrance shafts or lay, as individual skeletons, near an entrance. Limited water transport (2–10 m) of some fossils had occurred at some sites, for example The Morgue. (sites 10,12,13a,17,18,19).

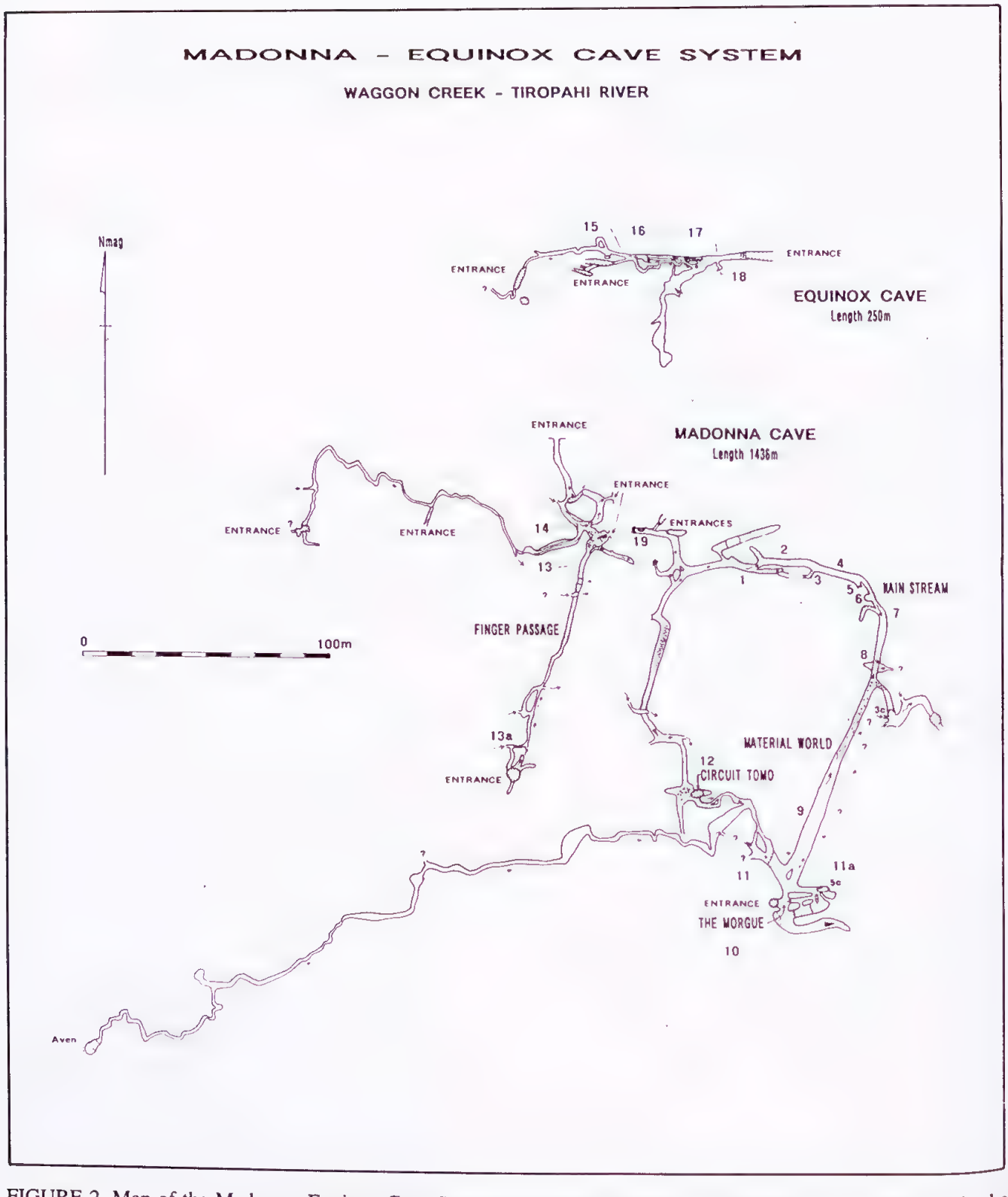

FIGURE 2. Map of the Madonna: Equinox Cave System showing the location of fossil sites 1–19 referred to in the text.

1. Water transported fossils.

Main Stream. Fossils at sites 1–8 were found in allochthonous deposits as isolated bones in the floor of the streambed. After recording all fossils it was decided that generally only femora would be collected leaving other fossils *in situ* for future cave visitors to see. The fossils collected represented all species and the maximum number of individuals present in sites 1–8 (MNZ S28055–28065) (Table 1). The exception to the policy of collecting femora was in site 8 where a tarsometatarsus of *Pachyornis* (S28064) was collected since this taxon was otherwise unrepresented. The majority of fossils were little worn and were whole bones, but at the most downstream part of the stream (site 8) a few very worn fragmentary bones of species not otherwise represented in the fauna were found. These included a distal left femur and a distal left tibiotarsus of *Pachyornis* and a distal right tarsometatarsus of *E. geranoides*.

The age of the majority of fossils in sites 1–8 was considered likely to be Holocene with the few worn specimens (detailed above) interpreted as probably reworked from older sediments. One bone of *A. didiformis* K30/f62b (assumed 'young'), and another, part of *P. elephantopus* S28064, K30/f62a, (assumed 'old') were dated to test this (Table 2).

Near site 1 a small side-passage on the true right had several fossil moa bones scattered along its terminal crawlway. These were not collected and were considered to be a sub-sample of the fauna in the main stream sites 1–8. Bones of *Dinornis novaezealandiae* and *Anomalopteryx didiformis* were seen.

Fossils at sites 14 and 15 lay in the bed of the stream. Both sites were similar in that they were about 10 m above the Main Stream in passages whose sediment banks had a different sequence of sediments to that seen in the Main Stream. I interpreted this to mean that the passage around sites 14 and 15 had escaped the last period of sedimentary infill and re-excavation that the Main Stream had been subjected to. As the small streams in these passages come from shaft entrances it was postulated that moas of both Holocene and pre-Holocene derivation could be present. All specifically recognisable bones were collected from site 14 and a *Pachyornis elephantopus* bone, chosen because this taxon was not present in the assumed young sites 10 and 12, was dated. Fossils found in the stream bed at site 15 were left as reference specimens.

2. Fossils enclosed in fluvial sediments

All along the Main Stream there were remnant banks of sediment reflecting an earlier period of sedimentation followed by erosion. Near site 8 two bones were observed apparently *in situ* near the top of the sediment bank: one an *Anomalopteryx didiformis* femur was left *in situ*, and the other, a femur of a juvenile *Dinornis* MNZ S28218, was collected. Opposite where the stream sinks another fossil (MNZ S28079), of undetermined moa species, was collected from about 0.5 m below the top of the sediments. Because these sediments

TABLE 1. The identity of 63 moas represented in collections from Madonna Cave, or by *in situ* material, and their distribution within sites is summarised here. Specimens marked * represent individuals known from *in situ* material only. All the rest are represented by collected specimens that were chosen to represent the total material from the site and so MNI at each site would not increase with further collecting even though many bones remain.

Site	*A. did.*	*M. did.*	*D. str.*	*D. nov.*	*D. gig.*	*E. ger.*	*P. ele.*
1–8	6	0	2	2	0	1*	1
9	0	3	1	0	0	0	0
10	5	5	2	8	1	0	0
11	0	1	0	0	0	0	3
12	3	1	1	1*	0	0	0
13	0	1	0	0	0	1	1
13a	1	0	0	0	0	0	0
14	3	0	1	0	0	0	1
15	0	0	0	1*	0	0	1*
16	0	0	0	0	0	2	1
17	0	0	0	1*	0	0	0
19	1*	0	0	0	0	0	0
Total	19	11	7	13	1	4	8

border an active stream and are no more than 0.5 m above the normal water level they are probably considerably younger than those hereafter described.

Site 11. This site was at the south end of Material World. The limestone floor of the passage was visible at the end of this passage but remnant sediment banks extended to the roof on both sides. At site 11 the sedimentary sequence was as follows: about 0.5 m of stream gravels and sands rested on the limestone floor. The gravels were overlain by a 0.5 m thick layer of slightly rounded limestone cobbles embedded in sand which was, in turn, overlain by homogenous sands that filled the 0.2–0.3 m space between the cobble layer and the roof. Immediately west of site 11, a 2 m bank overhung a streamway, but the passage leading upstream via the crawl (see map), preserved the sequence of sediments very well. Also, half way up the passage towards Circuit Tomo, an alcove preserved the same sedimentary sequence. There the available roof space above the cobbles was much greater and the sand layer much thicker. Immediately east of The Morgue the passage roof was also much higher and the sedimentary sequence was preserved in several places showing the sand layer was at least 3 m thick. Fossils were found at the interface of the sand and cobble layers : two bones (MNZ S28076, S28080) at site 11, and one at site 11a that was left *in situ*. Two fossils (MNZ S28077–8) were recovered from the crawl immediately west of site 11. Although not *in situ* preservation characteristics and adherent matrix indicated they had been dislodged from the same layer. Part of the *M. didinus* femur collected from *in situ* in site 11 was dated.

Site 13. Stream laid sand and gravel banks indicated that this area of the cave had been infilled to the roof. Worn fossil bones from single individuals of *Megalapteryx* MNZ S28082, *Pachyornis* MNZ S28081 and *Euryapteryx* MNZ S28083 were scattered on the surface of the floor formed on the eroded surface of these sediments. In one of the remnant banks of sediment lining the site, *in situ* fossils from these individuals were recovered, indicating that those fossils on the surface had been eroded from the sediments. One of the eroded *Euryapteryx* bones recovered from the surface of this site was dated.

Site 16. Here exactly the same sequence of sediments as seen at site 11 was preserved. Some fossils (MNZ S28121) were exposed on the surface but excavation revealed that other fossils were deposited on top of the limestone cobble layer (MNZ S28220–223). Several were found embedded in sand adjacent the upstream end of a large fallen rock where the stream had apparently washed them. About one metre 'upstream' of this rock, a remnant bank of sediment overlying the cobbles was found to contain an articulated series of moa vertebrae MNZ S28224 at a depth of three to four centimetres and about 30 cm above the sand cobble interface. These are most probably the surviving parts of the skeleton otherwise represented by S28121. This skeleton was deposited near the end of the deposition period as a whole carcass. The femur of S28121 was dated to provide a minimum age for the site and the more deeply buried disarticulated material.

3. Fossils accumulated near entrances

The most significant site was The Morgue, site

TABLE 2. Radiocarbon dating results from Madonna Cave. Specimens are identified by species, site of origin, Fossil Record Number FRN, and the laboratory sample number NZA (Accelerator mass spectrometry laboratory) or NZ (Gas counting laboratory).

Site	Species	FRN	NZA or NZ[1]	Radiocarbon age
8	*P. elephantopus*	K30/f62a	2505	14740±110
8	*A. didiformis*	K30/f62b	2443	2197±86
10	*A. didiformis*	K30/f65a	2506	5447±87
10	*D. novaezealandiae*	K30/f65b	7925[1]	5893±88
10	*D. giganteus*	K30/f65c	7926[1]	2829±75
10	*M. didinus*	K30/f65d	2503	782±83
11	*M. didinus*	K30/f67	2780	13150±140
12	*A. didiformis*	K30/f66	2521	1076±83
13	*E. geranoides*	K30/f63	2779	11090±100
14	*P. elephantopus*	K30/f64	2446	20680±160
16	*E. geranoides*	K30/f61	2445	23780±210

10. Here an entrance shaft at least 15 m deep was the natural trap that had accumulated a large amount of material in an autochthonous deposit. The history of sedimentation in the adjacent passages was one of deposition, wherein the sequence recorded for site 11 was deposited, followed by erosion right back to floor level to leave only sediment remnants along some walls and in alcoves. Only following this erosion event could the fossils observed at The Morgue have started to accumulate, and therefore they must all be younger than those seen in site 11. The base of the entrance shaft intersects a passage aligned approximately north-south which, either side, is only 0.5 m high. The water that formed the shaft now drains via a 20–30 cm high bedding-plane passage to the east. Although impenetrable this bedding can be approached via a small passage from the east that starts at the top of a 5 m drop, below which the water ultimately sinks away in gravels. Fossils were mostly collected from the base of the entrance shaft and from the bedding plane passage and its downstream outlet (MNZ S28088–28112, 28114–28120). Articulated remains of one subadult *Dinornis novaezealandiae* and one *Anomalopteryx didiformis* were found in the passage to the south indicating that these trapped birds had passed the low passage in this direction. Immediately north of the base of the entrance shaft an articulated skeleton of *A. didiformis* was left *in situ*. Fossils found at site 9 scattered along the floor of Material World are interpreted as remains of birds that were trapped by the Morgue entrance and passed the low passage to the north. It is significant that these are mainly from 3 individuals of *Megalapteryx*, the smallest moas in the region (MNZ S28067–28071). These small *M. didinus*, like others in site 10, are a small morph of the species identified by Worthy & Holdaway (1993) as only present in Holocene deposits in the area. One specimen in site 9 was a very worn, possibly reworked, femur of *Dinornis* (MNZ S28066). Four bones were dated from site 10, one from each of the following taxa: *Megalapteryx didinus, Anomalopteryx didiformis, Dinornis novaezealandiae,* and *D. giganteus* (from S28114).

Circuit Tomo: site 12. This site was at the base of another shaft entrance. Fossils were located in an autochthonous deposit of rockfall debris at the shaft base or scattered down the first few metres of the stream passage away from the shaft. Sediment banks with the same stratification as sediments preserved at site 11 indicate that fossils in site 12 had the same potential age range as those in site 10, and had to be younger than those in site 11. The *M. didinus* specimen was one of the small morphs of the species.

Other sites. A few fossils were recovered from site 13a. Bones of an individual *A. didiformis* were left in situ near the upstream entrance to the Main Stream (site 19). In Equinox Cave at site 17 a complete *D. novaezealandiae* skeleton was left *in situ* lying on the surface, and is necessarily younger than the fossils enclosed in sediments nearby at site 16. Closer to the entrance a small crawlway leads off and it contained some fossils, but none of moas.

Summary of Moa Distribution in Madonna Cave

Table 1 lists the individual sites described above and the moas, by species, from each of them: 63 individual moa are represented in the total collection. The geological ages for each site are indicated from the dates listed in Table 2. Sites 11, 14 and 16 are exclusively Otiran in age and contain *Pachyornis*, *Euryapteryx*, and *Megalapteryx*. Sites 10 and 12 are exclusively Holocene, and have *Anomalopteryx*, three *Dinornis* species with *D. novaezealandiae* the most abundant, and *Megalapteryx*. From the cave's sedimentary history site 9 should be associated with 10 and 12, and so is of Holocene age. Three dates were obtained from fossils found loose in streambeds; one from site 15, and two from the Main Stream sites 1–8. In the Main Stream the *Anomalopteryx* was late Holocene and in the *Pachyornis* Otiran. In site 15 the *Pachyornis* bone that was dated was Otiran in age.

Discussion

Allochthonous and autochthonous deposits in Madonna Cave contain fossils of various ages that can be regarded as autochthonous assemblages, that because of known age ranges provide useful palaeoenvironmental indicators. Deposits beneath shafts from the surface contain only Holocene faunas, fluvial sediments not in active streamways contain Otiran faunas, and streamways contain mixed Otiran and Holocene faunas. Holocene faunas were characterised by abundant *Anomalopteryx didiformis, Dinornis novaezealandiae, D. struthoides*, and small to medium morphs of *Megalapteryx didinus*. The

Otiran fauna contained no *A. didiformis*, but common *Pachyornis elephantopus* and *Euryapteryx geranoides*, with *M. didinus* as a medium to large morph only.

Local comparisons

A series of dates was obtained from moa bones from Te Ana Titi (Worthy & Holdaway 1993). The single *Pachyornis australis* individual was Otiran in age, and the *Dinornis novaezealandiae* of Holocene age. The 18 *Megalapteryx didinus* recorded from Te Ana Titi ranged from the largest ever recorded to nearly the smallest. The dates obtained by Worthy & Holdaway (1993) clearly showed that all the largest, without exception, were of Otiran age and the smallest, of Holocene age. These data support the hypothesis of post-glacial dwarfing proposed by Worthy (1988). It is therefore significant to note that the *Megalapteryx* recorded from the Holocene sites 9, 10 and 12 in Madonna were all small individuals.

Table 3 lists all moa individuals recorded from the Punakaiki karst area by Worthy & Holdaway (1993) regardless of specimen age. *A. didiformis* was the most abundant, with nearly twice the number of the next most frequently recorded species. This reflects the preponderance of Holocene sites and that this species was the most common in them. *Megalapteryx didinus*, the only species occurring in both Otiran and Holocene deposits, was the next most frequently encountered. *Dinornis struthoides* and *D. novaezealandiae*, the remaining common Holocene species were the next most abundant. The Otiran *Pachyornis* and *Euryapteryx* occurred in lower frequencies consistent with there being fewer surviving Otiran sites. *P. australis* and *D. giganteus* were very rare, and so in the Punakaiki karst were considered to have been outside of their preferred geographic ranges.

Comparison with other areas

The only place where comparable data has been obtained is Honeycomb Hill Cave System in the Oparara Valley, northwest Nelson. This area ranges in altitude from 200 – 300 m a.s.l.. There the Otiran moa fauna was dominated by *Pachyornis elephantopus, P. australis* and *Megalapteryx didinus*. *Euryapteryx geranoides* was extremely rare (one individual among hundreds), and *Dinornis novaezealandiae* and *D. struthoides* were both rare. In the Holocene *Pachyornis* and *Euryapteryx* were not recorded and *Anomalopteryx didiformis* dominated with *D. novaezealandiae* becoming more common (Worthy & Mildenhall 1989, Worthy 1993a). Data documenting changes in moa fauna over time have not been published for any other area.

Worthy (1990) described the 'Holocene' moa faunas for many regions in New Zealand. The Holocene faunas of western South Island, as shown by Honeycomb Hill Cave and the Punakaiki karst, were similar to those in lowland wet forest areas in Southland, and central, western areas of the North Island with *Anomalopteryx didiformis* and *Dinornis novaezealandiae* dominating in both. The Otiran faunas of the western South Island were most like the Holocene faunas of eastern areas of the South Island but there were significant differences. As seen above, in the west, *Megalapteryx didinus* accompanied *Pachyornis elephantopus* and *Euryapteryx*

TABLE 3. Summary of total numbers of moa individuals recorded from the Punakaiki karst area by Worthy & Holdaway (1993). MNI in coll. is minimum number of individuals determined from specimens in museum collections (some of which are voucher specimens for more material in the fossil site). MNI in situ refers to those recorded from the cave site only, and for which no voucher specimen was collected.

Dinornithiformes	MNI in coll.	MNI in situ	Total No.	(%)
Anomalopteryx didiformis	75	6	81	(40.3)
Megalapteryx didinus	28	10	38	(18.9)
Pachyornis elephantopus	11		11	(5.5)
Pachyornis australis	3		3	(1.5)
Euryapteryx geranoides	17		17	(8.4)
Dinornis struthoides	24	1	25	(12.4)
Dinornis novaezealandiae	22	2	24	(11.9)
Dinornis giganteus	2		2	(1.0)
TOTAL	182	19	201	

geranoides, but in the east, although the latter two species were common, they were accompanied by *Emeus crassus* (unknown in the west) and *D. giganteus* (very rare in the west).

The western Otiran fauna was more similar to that in Otiran loess deposits in eastern South Island where *Pachyornis elephantopus* dominated with *Euryapteryx geranoides* the next most abundant species. *A. didiformis*, *M. didinus*, and *D. novaezealandiae* were not present and *E. crassus, D. giganteus* and *D. struthoides* were rare (Worthy 1993b). On Takaka Hill in northwest Nelson the Otiran fauna consisted of rare *M. didinus,* and common *Pachyornis elephantopus*, *P. australis* and *E. geranoides* (Worthy unpubl. data).

The western distribution of moas in their dated context support previous notions of habitat preference of individual species (Worthy 1990). The mainly western distribution of *M. didinus* in both Otiran and Holocene periods suggests that it preferred wetter and cooler habitats. Generally it was an upland bird of the montane forests to the subalpine zone (Worthy 1988, 1989b). However, in the Holocene forests of the Punakaiki area, the only known lowland population of *M. didinus* was represented by a race where individuals were smaller than *Anomalopteryx* and their upland counterparts. It is possible that the small size of individuals enabled this population to avoid competition with *A. didiformis* which was the only other emeid present. Elsewhere populations of these two species met in ecotones in the montane forest zone and were separated by altitude (Worthy 1990). *P. australis* was rare in both time periods in Punakaiki. An abundance in Otiran Honeycomb Hill Cave and Takaka deposits compared to its presence mainly in subalpine deposits during the Holocene indicate that it was an upland species (Worthy 1989a, 1989b). In contrast *P. elephantopus* and *E. geranoides* were both common during the Otiran in a range of areas, including lowland eastern areas and western sites from sea-level to 700 m, but during the Holocene were only in eastern dry lowland areas. These observations support the hypothesis that these taxa preferred relatively openly vegetated areas where mosaics of grass and shrubland dominated the vegetation.

Conclusion

The data presented here clearly show that there were marked changes in distribution of moa species on the West Coast of the South Island between the last Glacial period and the Holocene. Usually only 3 to 4 species co-existed at one time and so moa species assemblages could be used as stratigraphic indicators. The presence of *E. geranoides* and *P. elephantopus* are indicative of Otiran age deposits and *A. didiformis* and *D. novaezealandiae* Holocene deposits. In addition to changes in species distribution *M. didinus* exhibited marked post-glacial dwarfing. The smallest and largest forms (defined Figure 26, Worthy & Holdaway 1993) are therefore useful stratigraphic indicators for the Holocene and Otiran periods respectively. The national implication of these data is that faunas from different sites should not be amalgamated into a regional fauna and analysed as a unit without reference to temporal variation unless temporal association is first proven. Cave systems throughout New Zealand can be expected to have superimposed Otiran and Holocene faunas and only careful study of stratigraphy combined with dating will separate them.

Acknowledgments

The study was funded by a grant from the Foundation for Research, Science and Technology. Dating of bone samples was supported by a grant from the Lottery Science Research fund administered by the NZ Lottery Grants Board. It would not have been possible without the hard work of my field assistant Anne Melhuish, nor the support of the Department of Conservation on whose land the study site lies.

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AN EXTINCT NEW SPECIES OF CORMORANT (PHALACROCORACIDAE, AVES) FROM A WESTERN AUSTRALIAN PEAT SWAMP

G. F. VAN TETS

VAN TETS, G. F. 1994. An extinct new species of cormorant (Phalacrocoracidae, Aves) from a Western Australian peat swamp. *Rec. S. Aust. Mus.* **27**(2): 135–138.

Microcarbo serventyorum n.sp. is described from a pelvis with proximal parts of the femora and some caudal vertebrae, which were found in a peat swamp at West Bullsbrook, north of Perth, Western Australia. Age is not known, but is probably Holocene. These bone exaggerated the pelvic differences between those of small extant species of *Phalacrocorax* and *Microcarbo* and are therefore included as a new species in the latter genus. Presumably *M. serventyorum* was able to forage in even more confined waters than other species of *Microcarbo*.

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At the 16th International Ornithological Congress in Canberra, I postulated that Australasia might be the main centre of generic and sub-generic divergence of the extant Phalacrocoracidae (van Tets 1976). Since then Siegel-Causey (1988) raised my generic separation of cormorants, *Phalacrocorax* versus shags, *Leucocarbo* to that of the subfamilies Phalacrocoracinae and Leucocarbinae. I agree with these subfamilies (van Tets pp. 808–809 in Marchant & Higgins 1990), but disagree with some of Siegel-Causey's generic and specific arrangements in those subfamilies. In particular I accept as cormorants in the Phalacrocoracinae only *Microcarbo* and *Phalacrocorax* including the sub-genus *Hypoleucos*.

Evidence for a new extinct Australian species of cormorant is provided by a pelvis with proximal parts of the femora and some caudal vertebrae (Figs 1–4). They were found 9 January 1970 in a peat swamp at mining lease 19H 'Melaleuca', West Bullsbrook, at 30 km north of Perth, Western Australia (31°41'S 115°59'E). They were noticed on a stockpile, before loading on to a truck, but after rotation and blading, from an estimated depth of about one foot (=0.3 m). Age is not known, but is probably late Holocene. C. Mizen forwarded it per A. R. Burns to Duncan Merrilees at the Western Australian Museum, who registered it 12 February 1970 as WAM 70.2.10.

WAM 70.2.10 was compared with a wide range of material in the collections of the Australian Museum (AM) Sydney, the Australian National Wildlife Collection (ANWC) CSIRO Canberra and the University of Michigan Museum of Zoology (UMMZ) Ann Arbor. The material included all families and genera of Pelecaniformes and most species of Phalacrocoracidae including all of *Microcarbo* (*sensu* van Tets 1976).

SYSTEMATICS

In penguins (Spheniscidae), darters (Anhingidae), cormorants and shags (Phalacrocoracidae), the cranial facet of the pelvis is convex and not concave as in frigatebirds (Fregatidae), gannets and boobies (Sulidae), nor saddle-shaped as in pelicans (Pelecanidae), tropicbirds (Phaethontidae) and in almost all other kinds of birds.

The pelves of the Spheniscidae differ from those of the Anhingidae and Phalacrocoracidae by having a fenestrated preacetabular ala of the ilium and lacking ventral spines (van Tets & O'Connor 1983). On the pelves of the Anhingidae prominent ilial crests flank the median dorsal ridge and shield (Olson 1975) and on those of the Phalacrocoracidae only the caudal half of the shield. In the shield there are up to six pairs of postacetabular foramina in Anhingidae and up to eight in Phalacrocoracidae. These foramina are relatively smaller in Anhingidae than in Phalacrocoracidae.

On the femur, the trochanter is about as tall as the head in Phalacrocoracidae and not lower as in WAM 70.2.10, Anhingidae and Sulidae (van Tets *et al.* 1989).

On the ilia lateral to the first pair of postacetabular foramina is a pair of rough

FIGURE 1. Dorsal view of pelvis. Left: *Phalacrocorax sulcirostris* ANWC BS–1310. Right: *Microcarbo melanoleucos* ANWC BS–1419.

FIGURE 2. Dorsal view of pelvis. *Microcarbo serventyorum* WAM 70.2.10.

irregular 'facets', which are about as wide as broad in Phalacrocoracinae and are longer than broad extending alongside the second pair of foramina in Leucocarbinae, but are variable and intermediate in the Pied cormorant, *Phalacrocorax varius*, and the Black-faced shag, *Leucocarbo fuscescens*.

The first four pairs of postacetabular foramina are about twice as long as wide in *Phalacrocorax* and relatively broader and less than twice as long as wide in *Microcarbo*. The concave preacetabular lateral edge of ilium is relatively long in *Microcarbo* and short in *Phalacrocorax*. The pelvis is relatively longer and more slender in *Phalacrocorax* than in *Microcarbo*.

Because WAM 70.2.10 fits the above characters of *Microcarbo*, except for the femora, I propose a new specific name for it.

Microcarbo serventyorum sp. nov.

Etymology

In honour of the Serventy brothers, Dom and Vincent, for their contributions to our knowledge of the Australian cormorants and shags (Serventy 1938, 1939, Serventy & White 1943, Serventy *et al.* 1971).

Diagnosis

A cormorant slightly smaller than species of *Microcarbo* and *Phalacrocorax*, relatively long preacetabular concave lateral edge on ilium; relatively broader first four pairs of postacetabular foramina adjacent to narrower ilia, and much larger 8th pair than in species of *Microcarbo* and *Phalacrocorax*. Parapophyses between 7th and 8th pair extend cranio-laterally and not laterally as in *Microcarbo* and *Phalacrocorax* (See figs 1–4).

Measurements of WAM 70.2.10 are generally more than ± 3 sd away from mean measurements of the smallest extant species of *Phalacrocorax*, and differ from all extant species of *Microcarbo*. These differences are most marked in the length of the dorsal ridge of the pelvis, the length of the 8th postacetabular foramen, and the proximal width of the femur (Table 1).

FIGURE 3. Caudal view of left femur. Left: *Microcarbo* ANWC BS–1419. Right: *Phalacrocorax sulcirostris* ANWC BS–1310.

FIGURE 4. Caudal view of left femur. *Microcarbo serventyorum* WAM 70.2.10.

Holotype

WAM 70.2.10, a pelvis with associated femora and caudal vertebrae.

Discussion

Australasia has four sympatric species of cormorants that occur on inland waters, which is more than anywhere in the world. Two are large, the Great cormorant, *Phalacrocorax carbo*, and the Pied cormorant, *P. varius*, and forage in rivers and large lakes and lagoons. Two are small, the Little black cormorant, *P. sulcirostris*, and the Little pied cormorant, *Microcarbo melanoleucos*. *Phalacrocorax sulcirostris* forages mainly in flocks in open water and *M. melanoleucos* forages in ponds, streams and along edges of large water bodies. Species of *Phalacrocorax* swim rapidly with their feet behind the body, while species of *Microcarbo* swim slowly with their feet beside

TABLE 1. Measurements (mm) of pelves and femora of species of *Microcarbo* and *Phalacrocorax*.

A: $\bar{x}$ (sd, range, n)

	M. melanoleucos	*P. sulcirostris*	*P. olivaceus*
TL	82 (4, 73–88, 13)	97 (6, 84–113, 25)	102 (7, 95–109, 3)
WA	25 (1.4, 23–28, 15)	27 (1.4, 24–30, 25)	30 (2.3, 27–31, 3)
LF	2.8 (0.4, 2.0–3.3, 14)	3.2 (0.3, 2.6–3.9, 25)	3.3 (0.4, 2.9–3.6, 3)
PW	11 (0.7, 9–12, 14)	12 (0.8, 11–14, 25)	13 (1.2, 12–14, 3)
DH	5.0 (0.3, 4.5–5.5, 14)	4.9 (0.3, 4.3–5.3, 25)	5.6 (0.6, 4.9–6.0, 3)
TL/WA	3.2 (0.13, 3.0–3.5, 13)	3.6 (0.18, 3.2–38, 25)	3.4 (0.17, 3.2–35, 3)

B: n = 1

	M. africanus	*M. coronatus*	*M. pygmaeus*	*M. niger*	*M. serventyorum*
TL	79	77	81	77	71
WA	25	26	26	23	22
LF	2.5	2.7	2.7	2.9	5.1
PW	11	11	11	9	7.5
DH	4.7	4.6	5.0	4.1	4.3
TL/WA	3.2	3.0	3.1	3.3	3.2

Abbreviations: TL = length of medium dorsal ridge of pelvis, WA = width between tips of antitrochanters, LF = length of 8th postacetabular foramen, PW = proximal width of femur, and DH = depth of head of femur.

the body. Exaggeration of pelvic features that distinguish extant species of *Microcarbo* from those *Phalacrocorax* suggest that *Microcarbo serventyorum* was even more adept at foraging in confined bodies of water. Its small size and discovery in a peat swamp suggest that *M. serventyorum* lived in marshes with dense vegetation, small pools and narrow creeks. It may have had a niche distinct from that of the other four species of cormorant and may have been part of the Australasian divergence I postulated (van Tets 1976).

Acknowledgments

I thank Walter Boles, Nick Klomp and Trevor Worthy for their comments on the text, the Western Australian Museum for making the holotype available for study, Dragi Markovic for the photography and Carolyn Roach and Jo Heindl for typing the manuscript.

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BIRDS FROM THE BLUFF DOWNS LOCAL FAUNA, ALLINGHAM FORMATION, QUEENSLAND.

WALTER E. BOLES & BRIAN MACKNESS

BOLES, W. E. & MACKNESS, B. 1994. Birds from the Bluff Downs Local Fauna, Allingham Formation, Queensland. *Rec. S. Aust. Mus.* **27**(2): 139–149.

A small number of bird fossils have previously been recorded from the early Pliocene freshwater, fluviatile and lacustrine deposits of the Allingham Formation, northwest of Charters Towers, northeastern Queensland. There has been several significant avifaunal discoveries made during recent excavations of the site, most of these being waterbirds. The number of taxa now recognised has almost trebled from previous published accounts and includes at least seven orders, ten families and 15 species-level taxa. A new subspecies of the Purple swamphen, *Porphyrio porphyrio nujagura* subsp. nov., is described. The earliest occurrences of the genera *Anhinga*, *Ardea*, *Cereopsis* and *Progura* in the Australian avifaunal fossil record are also reported. The potential role that the study of fossil birds can play in palaeoecological reconstructions is discussed.

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Birds have long been considered to be of secondary importance in the examination of fossil assemblages, with the paucity of their occurrence in the fossil record being cited as just one of the reasons for this cursory treatment (Olson 1985). The Australian fossil avifaunal record stretches back to the Cretaceous (Vickers-Rich 1991) and, although there has been a considerable increase in the investigation of fossil birds in recent years, most Tertiary studies have been taxonomic in nature, usually focussing on a single group (e.g. Miller 1963, 1966; Rich 1979; van Tets 1974). The interpretation of palaeoenvironments using fauna has relied almost exclusively on mammals, and indeed the 'Local Fauna' concept (Tedford, 1970) has this as its foundation.

In recent years, however, with an increasing number of palaeoornithologists working in Australia, birds are being used more and more both as biostratigraphic markers (Rich 1979) and as palaeoecological indictors (Boles 1993; Baird 1993).

A variety of taxa has been recovered from the early Pliocene freshwater fluviatile and lacustrine deposits of the Allingham Formation, northwest of Charters Towers, northeastern Queensland (Archer 1976, Bartholomai 1978, Archer & Dawson 1982, Archer 1982, Rich & van Tets 1982). Collectively this assemblage has been called the Bluff Downs Local Fauna (Archer 1976). The only bird mentioned in the original description of the fauna was *Xenorhynchus* [=*Ephippiorhynchus*] *asiaticus* (Archer 1976). Subsequently Rich & van Tets (1982) cited five taxa: *Xenorhynchus* cf. *X. asiaticus*, *Threskiornis* sp., cf. *Dendrocygna* sp., *Numenius* sp. and Charadriiformes. Rich *et al.* (1991) also listed five taxa: *Xenorhynchus* [=*Ephippiorhynchus*] *asiaticus*, *Threskiornis* sp., *Cygnus* sp., *Dendrocygna* sp. and *Numenius* sp. None of these listings offered further elaboration.

Materials and methods

Measurements were taken with vernier calipers accurate to 0.05 mm and rounded to the nearest 0.1 mm. Terminology of bones is primarily from Baumel (1979). Where comparisons were made with published measurements, the methods of measuring followed those adopted in the comparative study; otherwise these largely followed those illustrated by Steadman (1980). Specimens are currently held at the Queensland Museum. All the fossil material examined and all modern specimens used for comparisons were considered to be adults, based on the absence of a '. . . pitted surface of the bone and incomplete ossification of the articular facets' (Campbell 1979: 17).

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Systematics

PHALACROCORACIDAE

Phalacrocorax sulcirostris
(Fig. 1a,b)

Material

Proximal right humerus (QM F23242), distal right humerus (QM F23241), possibly from the same bone. Measurements: proximal width 16.8 mm, distal width 11.7 mm, depth of *condylus dorsalis* 7.9 mm. Locality: EVS Site.

Characters

The two fragments are considered to belong to the same species, and possibly the same individual, on the basis of size and configuration. The proximal end is referred to the Phalacrocoracidae on the basis of the reduced *crista pectoralis*, very broad *impressio m. coracorbrachialis* and broad, deep *sulcus ligamentosus transversus*. The distal fragment has a deeply excised *fossa m. brachialis*, which among extant Australian species occurs in *P. sulcirostris* and *P. varius* (Siegel-Causey 1988). The fossil agrees in size with *P. sulcirostris* (proximal width 16.2–17.2 mm, distal width 11.4–13.1 mm, depth of *condylus dorsalis* 7.9–8.6 mm), and is smaller than *P. varius* (proximal width 19.1–21.8 mm, distal width 13.1–14.1 mm, depth of *condylus dorsalis* 9.1 – 9.8 mm).

Remarks

The Little Black Cormorant is widespread in wetlands, prefering open water greater than one metre deep, including large lakes, areas with flooded or fringing trees, and swamps with permanent or semi-permanent water (Marchant & Higgins 1990).

ANHINGIDAE

***Anhinga* sp.**

Material

Proximal right humerus (QM F23653); right carpometacarpus (QM F25776). This material represents a new species and is being described (B. M.) elsewhere. Locality: QM F23653, EVS Site; QM F25776, Main Site.

Remarks

Darters prefer smooth, open water at least 0.5 m deep, including permanent waterbodies, large lakes with shallow vegetated edges and semi-permanent swamps (Marchant & Higgins 1990).

ARDEIDAE

cf. ***Ardea picata***
(Fig. 1e)

Material

Distal right tibiotarsus (QM F23243). Measurements: distal width 7.7 mm, depth of *condylus lateralis* 7.4 mm, depth of *condylus medialis* 7.9 mm. Locality: EVS Site.

Characters

The fossil is smaller and relatively more gracile than *Egretta novaehollandiae*, *E. garzetta*, *A. intermedia*, *Ixobrychus flavicollis* and *Nycticorax caledonicus*, but a good match in size and robustness for *Ardea picata* (distal width 6.3–8.0 mm, depth of *condylus lateralis* 6.5–7.6 mm, depth of *condylus medialis* 6.6–7.9 mm). It is not possible to assign the distal tibiotarsus to any particular genus of herons on morphological features. Payne & Risley (1976) found no consistent differences in the tibiotarsi within this family.

◀ FIGURE 1. Avian fossils from the Bluff Downs Local Fauna. Bars equal 10 mm. Bars are shared by **A** and **B**, and by **M**,**N** and **O**. Queensland Museum registration numbers are given in parentheses.
A. *Phalacrocorax sulcirostris*, proximal right humerus (F 23242); **B**. *Phalacrocorax sulcirostris*, distal right humerus (F 23241); **C**. *Threskiornis* sp. cf. *T. molucca*, cranial right coracoid (F 23257); **D**. *Threskiornis* sp. cf. *T. molucca*, distal right tarsometatarsus (F 23256); **E**. *Ardea* sp. cf. *A. picata*, distal right tibiotarsus (F 23243); **F**. *Ephippiorhynchus asiaticus*, proximal left humerus (F 23244); **G**. *Ephippiorhynchus asiaticus*, distal left humerus (F 23245); **H**. *Phoenicopterus* sp. cf. *P. ruber*, distal right tarsometatarsus (F 23252); **I**. *Dendrocygna arcuata*, proximal right humerus (F 23248); **J**. *Progura* sp. cf. *P. naracoortensis*, carpometacarpus (F 23258); **K**. *Progura* sp. cf. *P. naracoortensis*, proximal left tarsometatarsus (F 23259); **L**. *Porphyrio porphyrio nujagura* subsp. nov., proximal right tarsometatarsus (F 23250); **M**. Rallidae gen. and sp. indet. 2, distal left tarsometatarsus (F 23255); **N**. Rallidae gen. and sp. indet. 1, distal left tibiotarsus (F 23254); **O**. *Porzana* sp., distal left tarsometatarsus (F 23253); **P**. cf. *Numenius* sp., distal right femur (F 23251).

Remarks

Virtually all herons are associated with water, the type of wetland preferred and the manner in which it is utilised depending on the species. The Pied Heron occurs in shallow wetlands, including floodplains and swamps (Marchant & Higgins 1990).

CICONIIDAE

Ephippiorhynchus asiaticus
(Fig. 1f,g)

Material

Proximal left humerus (QM F23244); distal left humerus (QM F23245). Measurements: proximal width 44.8 mm, distal width 34.4 mm, depth of *condylus dorsalis* 18.7 mm. A '. . . fragment of tarsometatarsus (QM F7036)' cited by Archer (1976: 385) was not examined. Locality: QM F23244 AB Site; QM F7036, QM F23245 Main Site.

Characters

The proximal fragment agrees with the Ciconiidae and differs from the Gruidae, the only other similar taxon, by having *caput humeri* proportionally shorter, *intumescentia* less inflated and *fossa pneumotricipitalis* larger. The distal fragment resembles the former family, but not the latter, by having *tuberculum supracondylare ventrale* narrow and ridge-like, and *processus supracondylaris dorsalis* prominently produced.

Remarks

The Black-Necked Stork, Australia's only extant member of this family, inhabits mainly open water up to 0.5 m deep, including extensive sheets over grassland, shallow swamps and pools on floodplains (Marchant & Higgins 1990).

THRESKIORNITHIDAE

Threskiornis* sp. cf. *T. molucca
(Fig. 1 c,d)

Material

Cranial right coracoid (QM F23257); distal right tarsometatarsus missing *trochlea metatarsi IV* (QM F23256). Measurements: coracoid, cranial end of *processus acrocoracoideus* to caudal end of *cotyla scapularis* 20.6 mm, depth of *processus acrocoracoideus* 9.4 mm; tarsometatarsus, depth of *trochlea metatarsi III* *c.* 8.0 mm, dorsal length of *trochlea metatarsi III* 8.2 mm. Locality: QM F23256 EVS Site; QM F23257 Main Site.

Characters

The tarsometatarsus is assigned to *Threskiornis* rather than *Platalea* because *trochlea metatarsi II* agrees with the former in being less recessed plantarly relative to *trochlea metatarsi III* (in medial view). It agrees in size with *molucca* (depth of *trochlea metatarsi III* 8.4 mm, plantar length of *trochlea metatarsi III* 8.0 mm), which is larger than *spinicollis* (depth of *trochlea metatarsi III* 7.3–7.4 mm, plantar length of *trochlea metatarsi III* 7.1–7.3 mm).

Allocation of the coracoid to *Threskiornis* rather than *Platalea* is on the basis of having a narrower *processus acrocoracoideus* (in dorsal view), *cotyla scapularis* proportionally further from *processus acrocoracoideus*, and *processus procoracoideus* curving less mediad.

Living *T. spinicollis* and *T. molucca* are not separable on measurements that can be taken on the fossil coracoid (cranial end of *processus acrocoracoideus* to *cotyla scapularis*: *spinicollis* 20.4–21.8 mm, *molucca* 20.2–22.8 mm; depth of *processus acrocoracoideus*: *spinicollis* 11.7–12.1 mm, *molucca* 11.3–12.1 mm). These species differ somewhat in robustness of the shaft; however, damage to the Bluff Downs material precludes comparison. The coracoid is referred to the same taxon as the tarsometatarsus. Because material is limited and the living species are morphologically quite similar, a more definite identification is not made.

Remarks

The Australian White Ibis habitat preferences include shallow water over soft substrates, in swamps and open water, and muddy flats (Marchant & Higgins 1990).

PHOENICOPTERIDAE

Phoenicopterus* sp. cf. *P. ruber
(Fig. 1h)

Material

Partial distal right tarsometatarsus lacking *trochlea metatarsi IV* (QM F23252). Measurements: medial depth of *trochlea metatarsi II* *c.* 7.9 mm, lateral depth of *trochlea metatarsi II* 8.4 mm, dorsal width of *trochlea metatarsi III* 10.3 mm, lateral depth of *trochlea*

metatarsi III c. 9.1 mm, dorsal width of *trochlea metatarsi III c.* 7.6 mm, plantar length of *trochlea metatarsi III* 11.7 mm. Locality: Main Site.

Characters

This specimen is identified as a flamingo on the basis of the following characters (most from Rich *et al.* 1987): *trochlea metatarsi II* short relative to *trochlea metatarsi III*; distal end of *trochlea metatarsi II* broader than plantar border; *trochlea metatarsi II* twisted plantarly and laterally from front of tarsometatarsus; and *trochlea metatarsi III* narrow and deep. Reference of this fragment to this species is made on the basis of size rather than on diagnostic morphology.

The measurements of the Bluff Downs specimen are a good match for those of extant *P. ruber* given by Rich *et al.* (1987), and the specimen is therefore tentatively assigned to this taxon. This follows the practice of Rich *et al.* (1987: 207), who, faced with limited and undiagnostic material, segregated the forms on size and '. . . provisionally retained the generic and specific names that have priority as a convenience until more complete material allows a better evaluation of the systematic positions of the Pliocene and Quaternary flamingoes of Australia'.

Remarks

There are few records of flamingoes in Australia away from the centre of the continent. Rich *et al.* 1991 have recorded an undetermined flamingo from the late Miocene Alcoota Local Fauna, northern Australia. Living *P. ruber* of Africa frequents mainly saline or alkaline lakes, estuaries and lagoons, seldom alighting on fresh water (Brown *et al.* 1982). Similar conditions have been proposed for central Australian lake deposits yielding flamingo remains. The Alcoota Locality during the late Miocene is considered by Murray & Megirian (1992: 214) to have represented '. . . a small but permanent, possibly spring-fed pond or lake, sometimes expanding to a temporary, large, shallow lake.'

ANATIDAE

Cygnus atratus

Remarks

This taxon was cited by Vickers-Rich (1991) without further elaboration. This material has not been examined in this study. Locality: Main Site.

Cereopsis sp.

Material

A proximal carpometacarpus fragment (QM F23260). This material, probably representing the extant species *C. novaehollandiae*, will be described (B.M.) elsewhere. Locality: EVS Site.

Remarks

This species inhabits grasslands and terrestrial wetlands, occasionally entering water.

Dendrocygna arcuata

(Fig. 1i)

Material

Proximal right humerus (QM F23248). Measurements: proximal width *c.*18.3 mm, depth of *caput humeri* 6.0 mm. Locality: Main Site.

Characters

The Anserinae and Dendrocygninae are separated from other Anatidae by the combination of prominent capital shaft ridge directed towards the *caput humeri*, attachment for *caput ventrale* of *M. humerotriceps* extending virtually to *caput humeri*, and area of attachment of *M. pectoralis* on the *tuberculum dorsale* is elevated and somewhat circular (Woolfenden 1961). The Anserinae is unrepresented in Australasia except by the aberrant *Cereopsis*, which is diagnosable by several unique characters. The Bluff Downs specimen is an excellent fit for *Dendrocygna*, agreeing in size with *D. arcuata*, the smaller of the two Australian species.

Remarks

The Water Whistling-Duck prefers fresh, deep permanent waters with emergent vegetation (Marchant & Higgins 1990).

Nettapus sp.

Material

An almost complete left carpometacarpus (QM F23249). This material probably represents a new species and will be described (B.M.) elsewhere. Locality: EVS Site.

Remarks

Pygmy-geese are wholly aquatic on terrestrial wetlands, preferably deep (greater than 1m), permanent water bodies, with abundant floating

and submerged vegetation (Marchant & Higgins 1990).

MEGAPODIIDAE

Progura* sp. cf. *P. naracoortensis
(Fig. 1j,k)

Material

Carpometacarpus (QM F23258) lacking *os metacarpale minor*. Proximal left tarsometatarsus (QM F23259) lacking most of the *hypotarsus*. Measurements: carpometacarpus, proximal width (dorsal) 17.5 mm, (ventral) 15.0 mm; tarsometatarsus, proximal width 19.5 mm. Locality: EVS Site.

Characters

A tentative identification has been made on size. Van Tets (1974) published measurements for the two known species: proximal width of tarsometatarsus, *P. naracoortensis* 21–23 mm, *P. gallinacea* 26–29 mm; dorsal and ventral widths of carpometacarpus, *P. gallinacea* 27 x 16 mm; a carpometacarpus of *P. naracoortensis* was not available. The Bluff Downs material is smaller and older than that of either species. Here it is tentatively referred to the smaller *P. naracoortensis*, but it may represent an undescribed species.

The tarsometatarsus of *Progura* is separated from that of extant genera of Australian megapodes by the following combination of characters: hypotarsus situated more laterad, *sulcus hypotarsi* more laterally situated relative to *eminentia intercondylaris*, *cotyla medialis* nearly size of *cotyla lateralis* in cranial view with dorsal border rounded and projecting dorsally about the same extent as *cotyla lateralis*, medial border of *corpus tarsometatarsi* straight (less concave), and *sulcus extensorius* broader and deeper and extending further distad.

The carpometacarpus is distinguished by its combination of *processus extensorius* more proximally directed, proximal border of *facies articularis radiocarpalis* of *trochlea carpalis* rounded (not pointed), caudal border of *facies articularis ulnocarpalis* of *trochlea carpalis* rounded (not flattened) and extended ventrally only slightly more than *facies articularis radiocarpalis*, and *os metacarpale majus* slightly caudally curved.

Remarks

Previous records of *Progura* are from coastal and subcoastal areas of eastern and southeastern Australia. Not enough is known about the ecology of these animals for them to be useful bioecological indicators. Van Tets (1974) hypothesised that, based on relative leg lengths, the longer-legged *P. gallinacea* was a rainforest species, whereas *P. naracoortensis* inhabited open scrub land. Van Tets (1984) later suggested that, because these two species are usually found together, they could represent a single, sexually dimorphic species.

RALLIDAE

***Porzana* sp.**
(Fig. 1o)

Material

Distal left tarsometatarsus (QM F23253). Measurements: distal width 4.3 mm. Locality: EVS Site.

Characters

This specimen is larger than *Porzana tabuensis* (distal width 3.7 mm) or *P. pusilla* (3.3 mm) and about the same size as *P. fluminea* (4.3 mm) and *P. cinereus* (4.7 mm). Compared with these latter two species, *trochlea metatarsi* are thinner and more splayed, *trochlea metatarsi II* appears slightly less directed plantarad, and *incisurae intertrochlearis* are wider. The specimen is abraded on the trochlear surfaces, and some of these differences could be artefacts of this wear. Osteological characters given by Olson (1970) and Steadman (1986) between *P. cinerea* and other species of *Porzana* are not relevant to this partial element.

Remarks

Most rails are associated with water. The smaller species, including most *Porzana*, are usually shy, spending most of their time in dense waterside vegetation. *Porzana cinerea* also requires floating vegetation.

Genus and species indet. 1
(Fig. 1n)

Material

Distal left tibiotarsus (QM F23254). Distal width 5.1 mm, depth of *condylus lateralis c.* 5.3 mm, depth of *condylus medialis c.* 5.3 mm. Locality: EVS Site.

Remarks

The fossil represents a small to medium rail between the sizes of *Porzana cinereus* (distal width 4.2 mm, depth of *condylus lateralis* 3.9 mm, depth of *condylus medialis* 4.1 mm) and *Gallirallus philippensis* (distal width 6.0 mm, depth of *condylus lateralis* 6.0 mm, depth of *condylus medialis* 6.0 mm). There are several extant Australasian genera within this size range with which the specimen should be compared, *Dryolimnas* (*sensu* Olson 1973), *Rallina* and *Rallicula*.

Genus and species indet. 2.
(Fig. 1m)

Material

Distal left tarsometatarsus (QM F23255). Measurements: distal width 7.1 mm, depth of *trochlea metatarsi III* 3.8 mm. Locality: EVS Site.

Characters

This specimen comes from a larger and somewhat more robust species than the previous indeterminate rail. It is similar in size to *Amaurornis olivacea* (distal width 6.7–6.9 mm, depth of *trochlea metatarsi III* 3.2–3.6 mm) and *Gallinula ventralis* (distal width 7.4 mm, depth of *trochlea metatarsi III* 4.3 mm). This fossil is also similar in morphology to *A. olivacea*, and probably could be tentatively referred to that species; however, it seems prudent to await more extensive material and comparisons with a greater range of genera before taking this action.

Porphyrio porphyrio nujagura subsp. nov.
(Fig. 1l)

Material

Proximal right tarsometatarsus (QM F23250). Measurements: proximal width 9.7 mm, proximal depth 11.4 mm, length of *hypotarsus* 10.4 mm, width of *hypotarsus* 5.6 mm. Locality: EVS Site.

Characters

Agrees with *Porphyrio* and differs from other genera of Australian rails, including the genera of larger forms (*Gallinula*, including *Tribonyx*; *Fulica*; *Gallirallus australis*) by having a distally directed projection on the plantodistal end of the *hypotarsus* (in other genera, the *hypotarsus* curves smoothly into the shaft).

There are four Recent species of *Porphyrio* from Australasia: three flightless Australasian species (*mantelli*, New Zealand; *albus*, Lord Howe Island – extinct; and *kukwiedei*, New Caledonia – extinct; Balouet & Olson 1989); and *porphyrio*, the only member of the genus now occurring in Australia. The first three are much larger and robust than *porphyrio*. The Bluff Downs specimen shows no morphological differences from *porphyrio* but is smaller than either sex of this sexually size dimorphic species (Australian *porphyrio*: proximal width 10.7–12.5 mm, proximal depth 12.4–13.7 mm, length of *hypotarsus* 11.0–13.0 mm, width of *hypotarsus* 6.2–6.9 mm). Compared with measurements given by Steadman (1988: Table 2), it is also smaller than most extralimital populations of the *P. porphyrio* superspecies, except *P. porphyrio* from Bechuanaland and *P. poliocephalus* of Thailand.

Etymology

The specific name is from the Gugu-Yalanji dialect word *nujagura*, meaning 'prehistoric times' (Oates *et al.* 1964).

Remarks

The only extant Australian species of comparable size not examined was *Eulabeornis castaneoventris*, a mangrove specialist, for which no skeletons exist. The end of the shaft is jagged, indicating that the break occurred before fossilisation. This individual was probably a victim of a predator or scavenger. The Purple swamphen prefers permanent freshwaters with good cover of rushes and other larger waterplants, at least along the water's edge, usually in the proximity of more open grazing areas (Marchant & Higgins 1993).

SCOLOPACIDAE

cf. *Numenius* sp.
(Fig. 1p)

Material

Distal right femur (QM F23251). Measurements: distal width 10.0 mm, depth of *condylus lateralis* 8.7 mm, depth of *condylus medialis c.* 7.0. Locality: Main Site.

Characters

This specimen appears to represent a large sandpiper. It is substantially larger than all Australasian taxa except for *Numenius*, for which it is also a good match in morphology. Because

the distal femur has limited diagnostic value and the bone is slightly abraded, identification is not attempted beyond cf. *Numenius* sp.

Remarks

Some members of this family are restricted to coastal areas; others occur in freshwater wetlands (Lane 1987). Larger *Numenius* species are coastal, whereas *N. minutus* extends well into subcoastal regions.

Discussion

Taphonomy

All fossils were recovered from a series of massive lacustrine clays from Main Quarry (Archer 1976) and Elaine's Vertebrae Site (Mackness unpublished information). Most of the bones were not complete and showed post-depositional breakage and fragmentation. An exception was the tarsometatarsus of *Porphyrio porphyrio nujagura*, the jagged edge of which suggested predation or scavenging while the body was still relatively fresh. There was little evidence of transportation wear and, even though there was no articulation, it is probable that the birds died in reasonable proximity to the site of deposition. An examination of bone textures suggests that there was little subaerial prediagenetic exposure and that most bones were quickly buried or submerged.

Vickers-Rich (1991) suggested a bias in avifaunal fossil deposits toward medium-sized birds (e.g. ducks, flamingos, burhinids) and larger birds (emus) to the exclusion of smaller birds. Although the bird assemblage recovered to date is consistent with this prediction, large scale wet-screening of sediments presently being undertaken may result in the recovery of smaller birds. The depositional environment obviously favours the preservation of waterbirds: these are also common in central Australian Tertiary sites (Vickers-Rich 1991). The proportions of the different bone elements found fossilised at Bluff Downs are summarised in Figure 2. All are regarded to be the most durable elements (Napawongse 1981; Rich & Baird 1986; Vickers-Rich 1991).

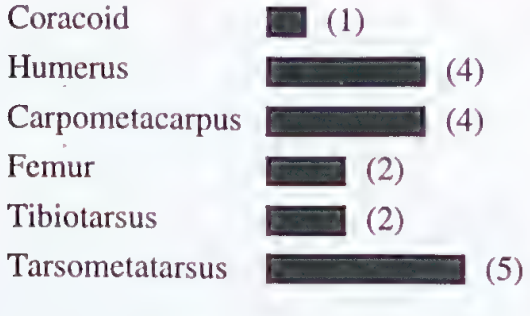

FIGURE 2. Summary of avian skeletal elements recovered from Bluff Downs Site.

Palaeoecology

Archer (1976) has suggested that the Bluff Downs Local Fauna may have been riparian. The large number of non-avian fossils recovered from the Bluff Downs site include both terrestrial and aquatic forms, with neither predominating. The mammals provide no definitive indication of what the terrestrial environment may have been like, although a typically rainforest-dwelling pseudocheirid possum is presently being described (B.M), along with an enigmatic family of marsupials (Mackness *et al.* 1993).

Three types of crocodiles have been recovered, including two large aquatic and one terrestrial form (Willis & Mackness in prep.). Studies of the molluscan fauna have revealed a diverse suite of species, some requiring specific aquatic niches that range from high energy fluvatile environments to stagnant lacustrine regimes (Mackness, unpublished data). It is evident from this faunistic 'mix' that there was a complex series of aquatic environments available either ephemerally or on a permanent basis.

Various authors (Frith 1959, Braithwaite & Frith 1969, Braithwaite 1975, Fjeldså 1985) have suggested a relationship between the distribution of waterbird species and habitat types. Fjeldså (1985) found poor correlation between avian communities and classifications based on vegetation types. Indicator species, e.g. *Porphyrio* and *Phalacrocorax*, are present in several of Fjeldså's classifications. Given the taphonomic evidence of minimal transportation and the nature of the sediments themselves, the Bluff Downs avifauna appears to be a biocoenotic assemblage, which may represent several depositional episodes. While most of the taxa identified, or their closest extant relatives, are relatively nonspecific in their preferences for wetland types, some utilise a range of microhabitats within wetland environments. Living species of *Nettapus* are more strict in their requirements than most, being generally confined to deeper water with considerable floating vegetation.

Living *Cereopsis novaehollandiae* graze on grasslands, whereas living phoenicopterids are

TABLE 1. Comparison of Australian Pliocene avifaunal assemblages. Data for Chinchilla and Kanunka from Rich *et al.* (1991) and Vickers-Rich (1991).

Family	Bluff Downs	Chinchilla	Kanunka
Casuariidae	–	X	X
Pelecanidae	–	X	X
Phalacrocoracidae	X	X	X
Anhingidae	X	X	X
Ardeidae	X	–	X
Ciconiidae	X	–	X
Threskiornithidae	X	–	–
Phoenicopteridae	X	–	X
Anatidae	X	X	X
Accipitridae	–	–	X
Gruidae	–	–	X
Megapodidae	X	X	–
Rallidae	X	X	–
Otididae	–	–	X
Scolopacidae	X	–	–
'Charadriiformes'	–	X	X

normally found in saline environments today. Disregarding these novelties, the remaining taxa comprise a waterbird community that differs little from that which now occurs in tropical Australia, such as in the wetlands of Kakadu National Park, Northern Territory, an area supporting seasonal floodplains, waterholes, rivers, ephemeral swamps and permanent lakes. From the avian assemblage, it is probable that at least part of Bluff Downs consisted of similar wetlands during the Pliocene.

Comparisons with other Pliocene faunas

Most Pliocene deposits have yielded bird fossils. Many are too fragmentary for identification while others have not yet been studied (Vickers-Rich 1991). Apart from the Bluff Downs Local Fauna, both the Chinchilla and Kanunka Local Faunas have significant avian components (Table 1). All three avifaunas are considered to be wetland assemblages, with the dominant families represented containing mostly wetland specialists. In these, most of the same families are represented. However long-legged wading birds (Ciconiiformes, Phoenicopteriformes) are absent from Chinchilla.

Acknowledgments

The authors wish to thank Michael Archer and Suzanne Hand (University of New South Wales) for providing helpful comments on the manuscript. Les Christidis and Rory O'Brien (Museum of Victoria), Jerry van Tets, (CSIRO Wildlife and Ecology), and Ralph Molnar (Queensland Museum) made specimens and/or comparative material available. Figure 1 was photographed and produced by Maurice Ortega, Stuart Humphreys, Lynne Albertson and Sally Cowan. Jack, Rhonda, Bram, Troy and Selesti Smith of Bluff Downs Station provided vital help and support for the ongoing research into the Bluff Downs Local Fauna. The collection of the Bluff Downs material was supported in part by: an ARC Program Grant to M. Archer; a grant from the Department of Arts, Sport, the Environment, Tourism and Territories to M. Archer, S. Hand and H. Godthelp; a grant from the National Estate Program Grants Scheme, Queensland to M. Archer and A. Bartholomai; and grants in aid to the Riversleigh Research Project from Wang Australia, ICI Australia and the Australian Geographic Society.

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MIMICRY IN ANKYLOSAURID DINOSAURS

TONY THULBORN

THULBORN, T. 1994. Mimicry in ankylosaurid dinosaurs. *Rec. S. Aust. Mus.* **27**(2): 151–158.

The tail club of Late Cretaceous ankylosaurid dinosaurs is usually regarded as a weapon to deter predators. However, the effective reach of the club was clearly constrained by the shortness and limited flexibility of the tail as a whole. Analogies with the defensive adaptations of butterflies and other insects indicate that the ankylosaurid tail club may represent a 'dummy head' that diverted predators from the true head. Simulated escape movements of that false head could have elicited the attack response of persistent aggressors, thus bringing them within striking range; thereupon the tail club would have performed its third function, as a weapon, to greatest effect. In performing such deceptive functions, the ankylosaurid tail club would qualify as an example of mimicry, seemingly the first to be identified among dinosaurs.

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Ornithischians of the suborder Ankylosauria are often epitomized as 'armoured dinosaurs' or 'reptilian tanks' on account of their exuberant developments of dermal bone (e.g. Charig 1979; Norman 1985; Carroll 1988; Coombs & Maryanska 1990). Among these dinosaurs the skull was protected by a helmet-like covering of osteoderms, while the neck, back, flanks and tail were shielded by a remarkable array of bony studs and plates, often elaborated into keels or spikes (Fig. 1). In addition, the members of one ankylosaur group, the family Ankylosauridae, carried a conspicuous deterrent weapon in the form of a bony club at the tip of the tail (Fig. 2). It is often supposed that ankylosaurids would sweep this weapon sideways to strike at the feet and legs of their aggressors (e.g. Charig 1979; Coombs 1979; Norman 1985).

Conventional thinking on the defensive capabilities of the armoured dinosaurs has been well summarized by Coombs & Maryanska (1990: 482–3):

> 'When attacked by predators, ankylosaurs primarily defended themselves passively, relying on their extensive armor and low-slung, difficult-to-overturn body conformation. Outrunning of predators seems unlikely. Ankylosaurids may have used their tail clubs for active defense by sweeping it just above the ground to strike at the fragile ankles of an attacking predator...'

This paper examines more closely the defensive capabilities of the ankylosaurid dinosaurs, giving particular attention to the role of the tail club.

The ankylosaurid tail club

The deterrent value of a tail club depends on its effective reach and, hence, on the length and flexibility of the entire tail. Surprisingly, the ankylosaurid tail was rather short and somewhat inflexible (Fig. 2). For instance, the ankylosaurid *Euoplocephalus tutus* possessed only 20 caudal vertebrae (excluding the first, which was joined to the sacrum, and an unknown number built into the terminal club); by comparison, the clubless tail of the nodosaurid *Sauropelta edwardsi* (family Nodosauridae) comprised 40 to 50 vertebrae (Carpenter 1982, 1984). Long transverse processes probably imposed some constraint on flexures at the base of the tail, and the distal caudal vertebrae were deeply internested, sheathed in ossified tendons and amalgamated into a rigid 'handle' to the tail club (Coombs & Maryanska 1990; Carpenter 1982). Consequently, the tail was flexible only in its proximal half, and then to a limited degree. It is inconceivable that the tail club could have been swung alongside the animal's flank, or across its back, or anywhere near the head, neck and shoulders.

It is sometimes implied that special defensive behaviour might have compensated for the limited reach of the tail club. For example, Norman supposed (1985: 168) that the ankylosaurid *Euoplocephalus* was sufficiently agile to avoid the lunges of a tyrannosaur while manoeuvring into position to retaliate. However, the exceptionally broad body of ankylosaurs probably conferred great stability (Carpenter 1984; Norman 1985;

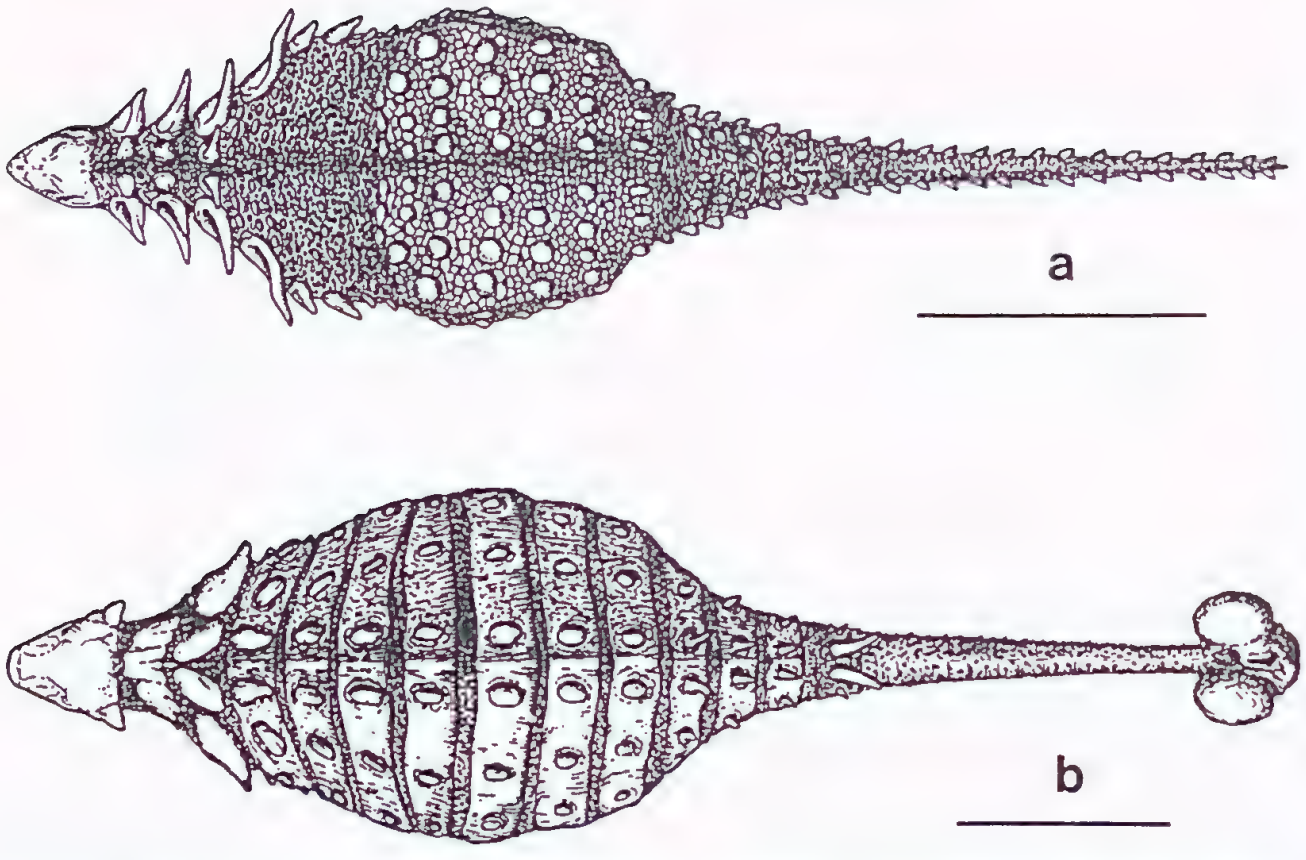

FIGURE 1. General body form of ankylosaurian dinosaurs. **a,** Restoration of the nodosaurid ankylosaur *Sauropelta edwardsi* in dorsal view (adapted from Carpenter 1984). **b,** Comparative restoration of the ankylosaurid ankylosaur *Euoplocephalus tutus* (adapted from Carpenter 1982). Each scale bar indicates 1 metre.

Bakker 1986; Coombs & Maryanska 1990), so that these animals were not easily overturned by predators. Such inherent stability is the antithesis of agility – which, in essence, is controlled instability. It is difficult to imagine that a single ankylosaurid, however agile, could turn rapidly enough to fend off two or more predators hunting in cooperation.

Overall, it seems as if the ankylosaurid tail club could have functioned as an effective weapon only if an aggressor strayed within the rather limited reach of the tail.

Behaviour of predatory dinosaurs

Big theropod dinosaurs, or 'carnosaurs' *sensu lato*, were probably the only predators capable of killing and dismembering the heavily-armoured ankylosaurids, which grew to a length of 6 metres and a weight of several tonnes. Presumably, carnosaurs attacked the most vulnerable regions of their prey, namely the head and neck. This strategy has several advantages (Ewer 1968): an attack to the head may confuse and disorient the prey, thereby reducing the risk of retaliation; there is great likelihood of inflicting fatal injuries—by severing or puncturing the spinal cord, the trachea or major blood vessels; and, finally, a rapid kill reduces the risk of attracting competitors and scavengers. A tendency to bite the neck or head of the prey is widespread among existing predators, including a variety of mammalian carnivores (Ewer 1968, 1973; Eaton 1970; Schaller 1972; Leyhausen 1973) and birds (Cade 1967; Scherzinger 1970; Ullrich 1971; Smith 1973), and experiments with hand-reared animals indicate that this may be an innate response (Leyhausen 1973; Lorenz & Leyhausen 1973; Smith 1973). The most important visual cues eliciting that response appear to be shape and motion of the prey. With respect to shape, experimental findings indicate that mammalian and avian predators tend to bite the most obvious constriction of the prey's body—which is usually the region of the neck. With respect to movement, those predators tend to bite the 'leading' end of the prey—which is usually the head.

Palaeobiological evidence surveyed by Molnar & Farlow (1990) does not rule out the possibility that carnosaurs used prey-killing techniques comparable to those of existing big cats, which

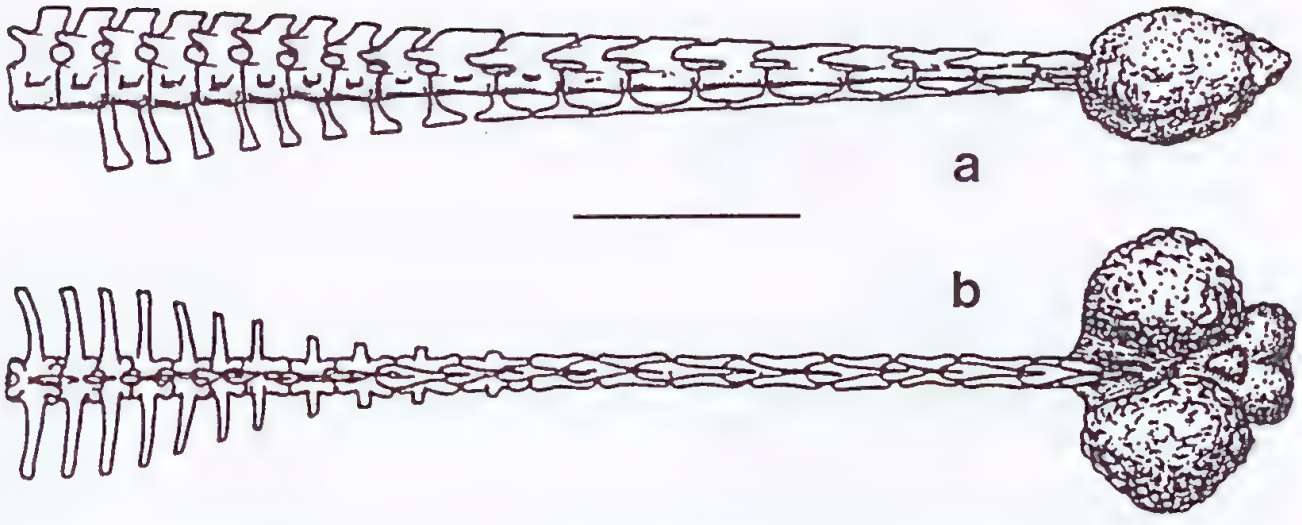

FIGURE 2. Tail skeleton of the ankylosaurid dinosaur *Euoplocephalus tutus*. **a**, Left lateral view. **b**, Dorsal view. Scale bar indicates 50 cm.

frequently employ a bite to the head or neck (Schaller 1967, 1972; Ewer 1973). This possibility does not imply that all carnosaurs adhered to a single pattern of prey-killing behaviour; rather, a tendency to seize the head or neck may be envisaged as a basic technique, which could have been modified (or even abandoned) to suit the circumstances of diverse carnosaurs.

It is noteworthy that many of the quadrupedal ornithischians susceptible to carnosaur attack (stegosaurs, ankylosaurids and nodosaurids) have a shallow skull that merges insensibly into a short neck. In effect, all these slow-moving herbivorous dinosaurs seem to have rendered the skull and neck as inconspicuous as possible. Among ankylosaurs there was also a tendency for the head and neck to be protected by a remarkable array of defensive structures. The head was encased in a veritable helmet of osteoderms, while the vulnerable region of the eye was shielded by a bony eyelid (Coombs 1972) and by an overhanging cornice of the skull roof. The shadow cast by this cornice may have concealed the eye, thus serving much the same role as a pigmented eye-stripe in many living animals (Cott 1940). In some ankylosaurs, such as the nodosaurid *Edmontonia rugosidens*, the neck was protected not only by its own covering of osteoderms but also by prominent bony spikes extending forwards from the region of the shoulder (Carpenter 1990, fig. 21.4; Coombs & Maryanska 1990, fig. 22.13). The existence of these elaborate defensive structures seems to confirm that the head and neck were particularly vulnerable regions of the ankylosaur body.

Theoretically, it is possible to test the suggestion that carnosaurs tended to attack the head and neck of their prey: such behaviour might be expected to result in an unusually high incidence of teeth-marks on the neck and skull bones of animals killed by carnosaurs. Unfortunately, several factors conspire to render this test impracticable. First, it seems that predatory dinosaurs left surprisingly few teeth-marks on the bones of their prey (Fiorillo 1991). Second, teeth-marks in regions other than the head and neck would result from predators and scavengers dismembering carcasses and stripping them of their flesh. Next, some teeth-marks would be lost if bones were swallowed and partly or wholly digested by carnosaurs (Fiorillo 1991). And, finally, it is possible that the head of the prey was consumed preferentially, as among domestic cats and other small carnivores (Leyhausen 1973; Ewer 1968). For those reasons, the distribution and abundance of tooth-marks is unlikely to provide any clear indication to the prey-killing behaviour of carnosaurs. Moreover, it is unrealistic to assume that all carnosaurs shared a single pattern of prey-killing behaviour; instead, they probably exploited a repertoire of killing techniques (Molnar & Farlow 1990), each appropriate to the identity, size, weaponry and behaviour of particular prey animals. An analogous situation exists among mammalian carnivores, where an extensive range of prey-killing techniques appears to have been developed from the basis of a straightforward neck-bite (Ewer 1973).

Heads and tails

The heads and tails of ankylosaurids show

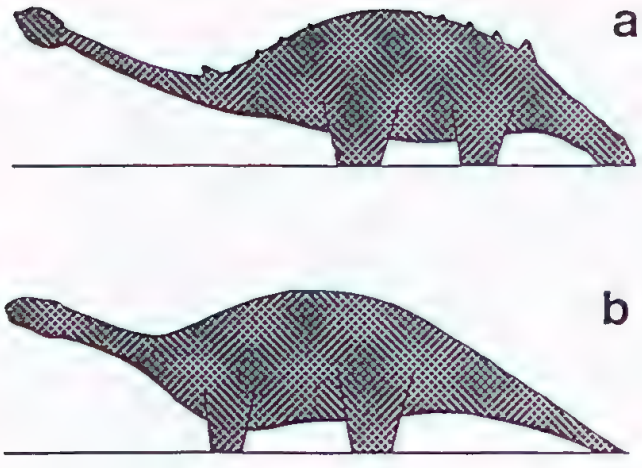

FIGURE 3. Silhouettes of dinosaurs, to illustrate potential role of ankylosaurid tail club as a 'dummy head'. **a,** The ankylosaurid dinosaur *Euoplocephalus tutus* (with head at right); feet and tip of snout are truncated, as if concealed by low vegetation, and the tail is raised. **b,** The ornithopod dinosaur *Iguanodon* in quadrupedal posture (with head at left); tail is truncated, as if lying on the ground or concealed by vegetation.

divergent modifications in form: the head was rendered as inconspicuous as possible whereas the visual impact of the tail was exaggerated by the terminal club of bone. The net result is that head and neck resemble a smoothly tapering tail, whereas the tail has much the profile of a long neck and prominent head (Fig. 3). This unusual body outline calls to mind those insects that carry a conspicuous 'dummy head' at the rear end of the body (Fig. 4). Such dummy heads appear to divert predators away from the true head and towards the least vital extremity of the insect's body (Cott 1940; Wickler 1968; Edmunds 1974; Curio 1976). It is suggested here that the ankylosaurid tail club was an analogous dummy head that served to deceive predatory dinosaurs.

Before pursuing that suggestion, it must be noted that the term 'dummy head' (or 'false head') seems to have been applied indiscriminately to two rather different adaptations among living animals. Here I propose to separate 'dummy heads' into two categories—'duplicate' heads and 'substitute' heads. In some animals the head and tail are virtually identical in shape, as among amphisbaenians, snakes, typhlopids and certain scincid lizards. Here the tail duplicates the form of the head, or *vice versa* (Wickler 1968), thereby confusing and disorienting predators (Wickler 1968; Bustard 1969). In ankylosaurids, and their insect analogues, the tail appears to be modified as a visual substitute for the head (and *vice versa*), evidently serving to draw the attention of predators away from the true head. Here the substitute head is more conspicuous than the true head. Although substitute heads may have originated through the elaboration of duplicate heads, the two adaptations are in many cases sufficiently distinct to warrant clear separation.

The substitute heads of ankylosaurids differ from those of insects in two important respects. First, the substitute head of an insect is disposable: its sacrifice may permit an insect to escape with minor damage (Cott 1940; Swynnerton 1926; Carpenter 1941). By contrast, the tail club of an ankylosaurid was not detachable. Second, insects can escape by jumping or flying, whereas ankylosaurids were probably incapable of outrunning theropod dinosaurs (Coombs 1978; Thulborn 1982, 1990). Ankylosaurids were obliged to stand and fight, and for that reason their substitute head is necessarily adapted as a robust deterrent weapon.

Insects possessing a substitute head often show appropriate peculiarities of behaviour (Cott 1940; Curio 1965, 1976; Wickler 1968). For instance, most butterflies rest head upwards on steep surfaces, but those with a substitute head

FIGURE 4. Butterflies of the genus *Thecla*, each with 'dummy head' (at left) bearing antenna-like filaments and eye-spot (adapted from Cott 1940; Wickler 1968).

frequently rest upside down. Butterflies of the species *Thecla togarna* instantly turn through 180° on alighting, so that the substitute head points in the previous direction of flight; then, on the approach of a predator, the butterfly appears to take off in the 'wrong' direction. In some cases the substitute head bears an eye-spot and antenna-like filaments whose movements simulate those of real antennae (Fig. 4), and butterflies of the genus *Deudoryx* have been reported to walk backwards. Given these examples, it is conceivable that ankylosaurids equipped with a substitute head might also have indulged in some form of deceptive behaviour.

Ankylosaurid defensive behaviour

The foregoing analogies and constraints provide a framework for the following new model of ankylosaurid defensive behaviour.

In normal circumstances ankylosaurids probably carried the tail club at ground-level; it is unlikely to have been carried so conspicuously as to attract the attention of predators. On the close approach of a predator, the tail may have been raised to become clearly visible (Carpenter 1984; Fig. 3a). If a predator moved in to attack, appropriate movements of the ankylosaurid tail could simulate those of a genuine neck and head. On luring the predator within reach of the tail club, the substitute head might be swung away as if it were attempting to escape. This apparent retreat of the prey's head could provoke the predator into lunging after it, whereupon the tail club would be swung back straight into the face of the predator.

According to this model, ankylosaurids did not struggle to manouevre the tail club into a position suitable for striking an aggressor; instead, the aggressor was lured within reach of the tail club. Also, the tail club would strike at the aggressor's head, rather than its feet, thereby achieving the greatest deterrent effect. The model requires that an aggressor should respond to the two most important visual cues known to affect the behaviour of existing predators: movement (the apparent 'escape' of the prey's 'head') and shape (the sharp constriction behind the prey's 'head'). Finally, a tail club disguised as a head would permit an ankylosaurid to deal with two or more predators, as each of them would fall prey to the same deception.

This model finds similarities in the defensive adaptations of certain molluscs and beetles. Many eolid molluscs have vividly coloured dorsal papillae, which may be erected and waved about on the approach of an aggressor (Edmunds 1966, 1974). The papillae contain nematocysts, as predators may discover to their cost. However, it is not clearly established that the papillae simulate items of prey, nor that their movements serve in distracting and luring predators; the papillae might equally well be interpreted as aposematic devices (Cott 1940). Similar uncertainties apply in the case of those carabid beetles that squirt an acid secretion from the tip of the tail. Although prominent white eye-spots may divert predators to the tail of the beetle (Marshall & Poulton 1902), these might, once more, be aposematic in function. In view of these uncertainties, it is impossible to identify any extant organism that duplicates the entire pattern of defensive behaviour proposed for ankylosaurids. Nevertheless, every component of that behavioural model has some counterpart among living organisms. For example, both snakes and cats are known to lure or distract other animals by twitching the tip of the tail (Wickler 1968; Carpenter & Ferguson 1977).

Mimicry?

If the ankylosaurid tail club did function as a substitute head, it would probably qualify as an example of mimicry. Certainly, it would exemplify Wickler's concept of mimicry (1965, 1968), which required the deception of a signal-receiver (usually a predator). The more restrictive definition proposed by Vane-Wright (1976) placed no emphasis on deception, but depended instead on the outcome of interactions between the mimic, its model and the signal-receiver. Vane-Wright specifically excluded 'decoys and deflective marks', including dummy heads, from the realm of mimicry. However, the ankylosaurid tail club may have been multifunctional – serving in turn as a deflective structure, a lure and a weapon. In performing the second of those functions, by luring an aggressor within reach, the tail club would merit inclusion in Vane-Wright's category II (synergic aggressive mimicry). The requirements of this category are: (1) that the mimic simulates an organism attractive to the signal-receiver, and (2) that on the signal-receiver's approach, the mimic interacts with it to the advantage of the model. In the case of ankylosaurids, the tail would simulate the generalized form of head and neck in other ornithischian dinosaurs (most obviously the

ornithopods, Fig. 3b). Those other ornithischians would derive advantage, in Vane-Wright's words (1976: 36), 'through the removal or debilitation of their predators'.

Such interpretation of the ankylosaurid tail club constitutes the first report of mimicry in dinosaurs. Although a tail club occurred in at least two genera of sauropod dinosaurs (Dong *et al.* 1989), this was comparatively small and might not have been functionally equivalent to that of ankylosaurids. Even so, the defensive model proposed for ankylosaurids might be extrapolated to certain stegosaurs, where conspicuous tail spikes (see Galton 1990) may have drawn the attention of predators before being employed as a deterrent weapon.

Discussion

Mimicry is a subject of enduring controversy among biologists. Wickler remarked (1968: 13) that 'one hundred years after Bates [1862] first clearly defined the concept of mimicry, a review of the literature listed 1 500 papers arguing for or against it. This amounts to roughly fifteen papers a year, or more than one a month.' Few examples of mimicry have been identified among vertebrate animals (Wickler 1968: 18), and not surprisingly this phenomenon is virtually unknown in the fossil record (Boucot 1990: 457). In these circumstances the foregoing hypothesis of mimicry in ankylosaurid dinosaurs might be regarded with some scepticism. It seems appropriate to examine two predictable objections to that hypothesis.

First, it may be objected that hypotheses about the behaviour of extinct organisms are not amenable to scientific testing. In the present case it is difficult to imagine how the behavioural interactions of ankylosaurids and their predators could ever be corroborated or falsified. Although this objection is certainly valid, it does not necessarily condemn the proposed model of ankylosaurid defensive behaviour to the realm of unscientific speculation. That model meets the stringent requirements of a scientific hypothesis in two respects—congruence and productivity.

With regard to congruence (or consilience), the model provides a single coherent explanation for all pertinent observations, particularly those concerning the anatomical peculiarities of ankylosaurids. By contrast, one conventional interpretation of ankylosaurid defensive behaviour involves a major inconsistency or internal contradiction: it requires that the ankylosaurid body plan should confer both great stability and a high degree of agility. To use a familiar analogy, that conventional interpretation requires that ankylosaurids should combine the stability of a four-wheel-drive vehicle with the turning circle and manoeuvrability of a motor-cycle. (Alternatively, one might try to envisage a single human possessing both the stability of a Sumo wrestler and the agility of a ballet dancer.) Such a combination of antagonistic physical properties may well be an unattainable ideal and it appears to be approached only in exceptional circumstances (e.g. in the case of a tank, or a bulldozer, with one caterpillar tread operating in reverse). Although there is a suggestion that stegosaurs were capable of fending off predators by pivoting very rapidly on the hindfeet alone (Bakker 1986), it seems much less likely that the broad-bodied ankylosaurids could have done so.

The model proposed in this paper meets the requirement for productivity by generating predictions that are (in theory at least) scientifically testable. One such prediction, concerning the distribution of teeth-marks left by predatory dinosaurs, was mentioned earlier. Two more predictions, derived from the general principles of mimicry, are: (a) that the mimics (ankylosaurids) should have inhabited the same environments as their models (ornithopods), and (b) that the mimics should have been less abundant than their models (Wickler 1968: 46–48). Yet another prediction stems from the suggestion that a substitute head may originate through the elaboration of a duplicate head: consequently, one might expect the ancestors of ankylosaurids to have possessed a tail that was similar in size and overall shape to the head and neck combined. By contrast, conventional interpretations of ankylosaurid defensive behaviour seem to generate only a single prediction—namely, that the lower leg and ankle were those regions of the carnosaur body most likely to sustain injuries during encounters with ankylosaurids. The model proposed in this paper offers a conflicting prediction—that such injuries were more likely to affect the carnosaur skull.

Second, it might be objected that the ankylosaurid tail bears only slight resemblance to the head and neck of an ornithopod, and that such a remote similarity would be unlikely to deceive a discriminating predator. This objection encapsulates the common belief that a successful mimic must show close and detailed resemblance to its model, on the assumption that some less exact resemblance to the model would be

inadequate to deceive a signal-receiver. Similar assumptions were adopted by Punnet (1915) and Goldschmidt (1945), who maintained that mimicry could not arise through gradual processes of natural selection because the initial chance resemblance between mimic and model would be so slight as to confer no advantage. However, this assumption appears to be groundless: experimental studies with birds, insects and artificial models reveal that some mimics can, and do, derive advantage from only superficial similarity to their models (Duncan & Sheppard 1965; Wickler 1968: 94; Edmunds 1974: 90–99). For instance, Brower *et al.* (1963: 80) stated 'as an experimentally demonstrated fact ... that even a remote resemblance between heliconiine butterflies can be advantageous' in conferring protection from predators. Moreover, it cannot be assumed that all predators are equally discriminating. Among birds, for example, the situation was summarized by Edmunds (1974: 92) as follows:

> it is likely that a whole spectrum exists from birds which recognize prey by a single visual cue, and are hence easily deceived by even a poor mimic, to birds which recognize prey by overall appearance or by many visual cues and which can distinguish almost perfect mimics from their models.

It is possible that a similar spectrum existed among theropod dinosaurs, with some identifying their prey by means of its overall appearance (*Gestalt* perception) while others relied on one or more specific visual cues, such as shape and direction of movement. The less discriminating of those predatory dinosaurs might well have been deceived by ankylosaurids equipped with a dummy head.

Acknowledgments

I thank Kenneth Carpenter, Colin McHenry, Ralph Molnar and Tom Rich for their comments and discussions—sometimes sceptical, but always encouraging.

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EMYDURA LAVARACKORUM, A NEW PLEISTOCENE TURTLE (PLEURODIRA:CHELIDAE) FROM FLUVIATILE DEPOSITS AT RIVERSLEIGH, NORTHWESTERN QUEENSLAND.

A. W. WHITE AND M. ARCHER

WHITE, A. W. & ARCHER, M. 1994. *Emydura lavarackorum*, a new Pleistocene turtle (Pleurodira: Chelidae) from fluviatile deposits at Riversleigh, northwestern Queensland. *Rec. S. Aust. Mus.* **27**(2): 159–167.

In 1986 the carapace, plastron and pelvic remains of a large chelid turtle were recovered from Pleistocene sediments on Riversleigh Station in northwestern Queensland. The fossil remains are described herein. The good state of preservation enabled the remains to be placed in an extant genus (*Emydura*) within the Chelidae on the basis of a derived feature of the carapace. Distinctive features such as a wide bridge, broad first vertebral scute, unusual epiplastra–hyoplastron suture, thickened bridge buttresses and deep intergular insertion between the humerals prevent these fossils from being assigned to a known species. Accordingly, a new species of *Emydura* is proposed and comparisons are made between it and the currently recognised congenors.

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Chelid fossil shell fragments are common in the Plio–Pleistocene deposits throughout Australia (e.g. in the Pliocene and Pleistocene deposits of the Darling Downs; Molnar 1982) but few are sufficiently complete to permit a detailed comparison with the shells of living species (Gaffney 1981).

In May, 1984 exploration of eroded fluviatile deposits exposed in the watershed of the Gregory River on Riversleigh Station, northwestern Queensland, revealed several sites that produced fossil vertebrates. One of these, now known as Terrace Site, produced abundant remains of chelid turtles as well as the Pleistocene marsupial *Diprotodon optatum*, unidentified macropodoids, murids, crocodilians, lacertilians, fish and invertebrates (bivalves and gastropods). Preliminary accounts of the discovery of Terrace Site have been given in Archer, Hand and Godthelp (1986).

From approximately 30cm above the base of the palaeochannel, in a layer with abundant bivalves and mammal bone fragments, a nearly complete although somewhat crushed chelid shell was recovered. It is sufficiently well preserved to enable comparison with a wide range of living chelids and is the basis for the species described herein.

Additional vertebrate remains from this deposit will be reported elsewhere (Godthelp, in preparation; Willis and Archer 1990; Willis, in preparation).

The anatomical terminology used in this paper follows that employed by (Gaffney 1977). That of modern chelid taxonomy follows Cogger (1993) and Obst (1986). Qualitative and quantitative methods of analysis follow Auffenberg (1976).

Methods

After being exposed in the deposit, the specimen was hardened with aquadhere, braced and secured in a plaster jacket. In the laboratory, various sections of the shell, defined by post-depositional crushing, were reconstructed using aquadhere. Measurements were made with dial calipers to the nearest millimetre.

Measurements and abbreviations used here are as follows:

Carapace

Anterior Carapace Width (ACW) = the anterior width of the carapace measured from the most anterior points of the $M_2 - M_3$ sutures.

Width of V_1 (V_1W) = the maximum width of the first vertebral scute.

Length of V_1 (V_1L) = the maximum length of the first vertebral scute.

Width and Length of Subsequent Scutes (Indicated by the appropriate subscript).

Length of C_1 (C_1L) = the maximum length of the first costal scute.

Plastron

Total Plastron Length (TPL) = measured in parallel to the midline from the most anterior to most posterior part of the plastron.

Anterior Plastron Length (APL) = measured in parallel to the midline from the most anterior portion of the plastron to the anterior margin of the bridge.

Bridge Width (BW) = the width of the bridge at the junction of the plastron.

Posterior Plastron Length (PPL) = measured in parallel to the midline from the most posterior portion of the plastron to the posterior margin of the bridge.

Intergular Width (IW) = the width of the intergular measured along the anterior margin of the plastron.

Intergular Length (IL) = the maximum length of the intergular scute.

Gular Width (GW) = the width of the gulars along the anterior margin of the plastron.

Gular Length (GL) = length of the gular-intergular suture.

Intergular Insertion (II) = the distance along the midline that the intergular scute penetrates between the humeral scutes i.e. measured from a line level with the posterior ends of the gulars to the posterior end of the intergular.

Humeral Length (HL) = the length of the humeral scutes along the midline.

Pectoral Length (PL) = the length of the pectoral scutes along the midline.

Abdominal Length (AL) = the length of the abdominal scutes along the midline.

Femoral Length (FL) = the length of the femoral scutes along the midline.

Anal Length (AnL) = the length of the anal scutes along the midline.

Anal Width (AW) = the distance between the most posterior parts of the opposing anal scutes.

Epiplastron Length (EpL) = the length of the epiplastron bones along the midline.

Entoplastron Length (EnL) = the maximum length of the entoplastron.

Entoplastron Width (EnW) = the maximum width of the entoplastron.

Hypoplastron Length (HyL) = the length of the hypoplastron bones along the midline.

Comparative Specimens Examined

Many of the comparative specimens of modern species examined during this study are lodged in the herpetological collections of the Australian Museum as follows:

Emydura australis: R20737, R72786, R72787.

Emydura krefftii: R14925.

Emydura macquarii: R1188, R6789, R81477, R85727, R104335, R123049

Emydura novaeguineae: R5042, R24460.

Emydura signata: R58588, R58589, R96716.

Elseya dentata: R3699, R3700, R31728, R36998, R40181,

Elseya latisternum: R20330–20345,R21224, R21485, R21570–21572, R37657–37665, R43530, R43542, R81958.

Rheodytes: R125481

Other specimens of these species were examined from the authors' collections. A specimen of *Pseudemydura umbrina* was examined from the Western Australian museum (WAM 13744). A specimen of the alpha taxon turtle was examined from John Cann's collection.

Systematics

Order: Testudines Linneus, 1758

Infraorder: Pleurodira (Cope, 1868)

Family: CHELIDAE Gray, 1825

Genus: ***Emydura Bonaparte***, 1836

Emydura lavarackorum White & Archer n. sp. (Figs 1,2,3 and 4)

Holotype:

Queensland Museum Palaeontological Collections no. F 24121, an associated almost complete plastron, partial carapace and pelvic fragments collected 9th May, 1986, by J. and S. Lavarack.

Type locality and age:

Terrace Site, an excavation in fluviatile sediments exposed on the south bank of the Gregory River, Riversleigh Station, northwestern Queensland, approximately 200km northwest of Mount Isa. More precise locality data are recorded and may be available on application to the Queensland Museum or the University of New South Wales. The presence in the sediments of material referable to *Diprotodon optatum* and no other index fossil indicative of any other period of time is the basis for interpreting the deposit to be Pleistocene in age. No more precise age determination is available at this time although samples suitable for radiocarbon dating have been collected.

Diagnosis:

This species differs from all others in the following combination of features. The first

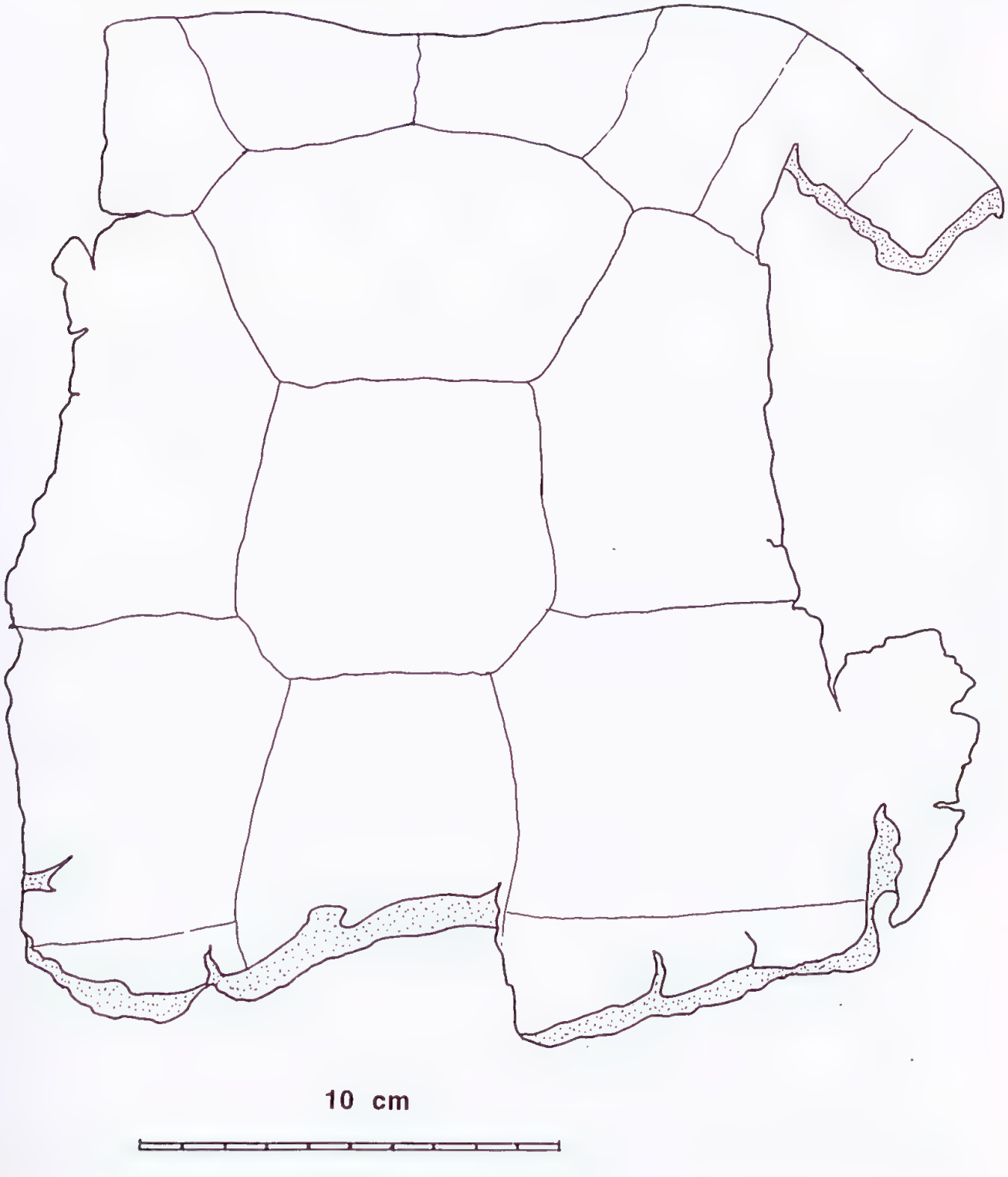

FIGURE 1. Dorsal view of anterior carapace of *Emydura lavarackorum*.

vertebral scute (V_1) is much wider than V_2. Vertebral scutes V_2 and V_3 are rectangular, being longer than they are broad, with very small projections into the costal junctions (Fig.1). The humeral–pectoral seam is sigmoidal rather than straight. The anterior straight edge of the carapace is wide and incorporates the two left and right marginal scutes (before the carapace curves posteriorly). The anterior bridge struts are unusually thick. The anterior edge of the gular is as wide as the anterior edge of the intergular. The intergular is long and deeply divides the humeral scutes. The intergular intrusion between the humerals is greater than the gular length. The intergular scutes narrow at the anterior edge of the carapace. The bridge is broad (BL:TPL = 0.29). The acetabulum is circular and is contributed to equally by all three pelvic bones. The acetabulum has a diameter of 25 mm. The upper (ilial) lip of the acetabulum is raised and overhanging whereas the lower lip (ischium and pubis) is less pronounced.

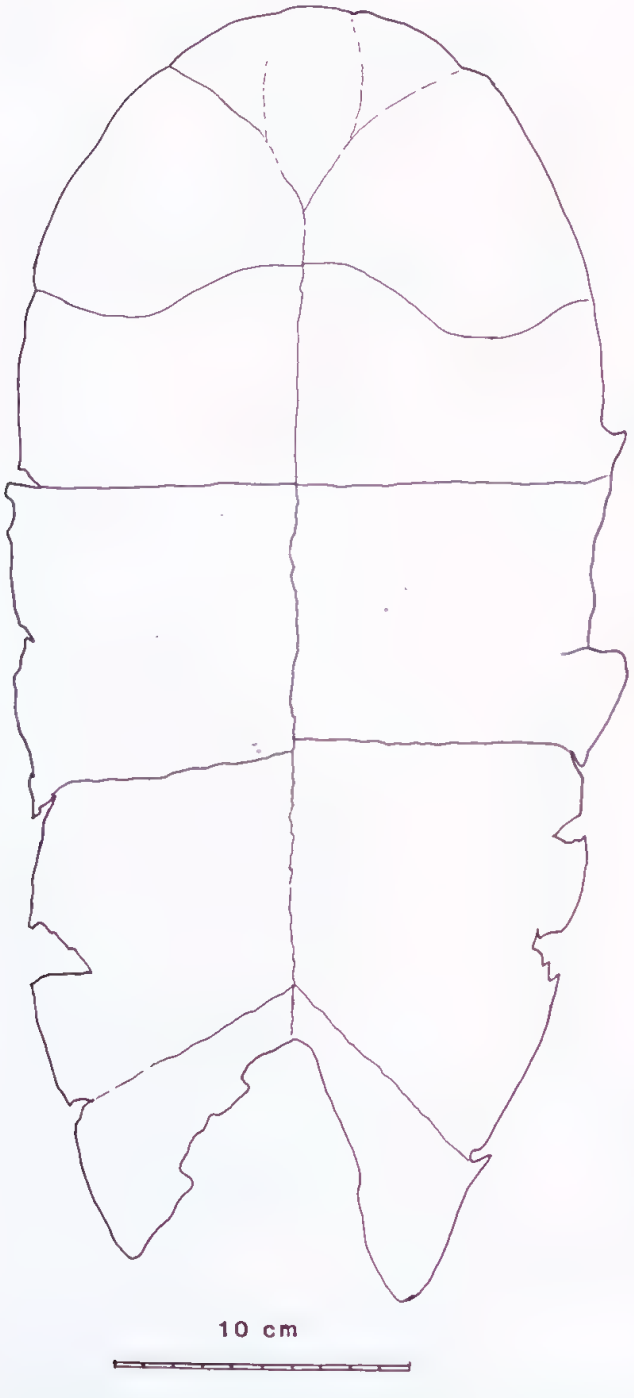

FIGURE 2. External view of plastron of *Emydura lavarackorum*

Etymology:

The species name is in honour of Sue and Jim Lavarack, hard-working volunteers who, besides having collected the holotype (Archer 1988) and supervised excavations at Terrace Site for five years, have maintained a continuous supportive role in the work done at Riversleigh and on Riversleigh materials which they have helped to prepare in Sydney.

Description:

The plastron is long (390 mm) and almost complete except for some medial gaps in the anal region (Fig. 2). The plastron is evenly rounded at its anterior end. The posterior end of the plastron terminates with two pointed anal projections. The anterior lobe of the plastron is broader (maximum width 165 mm) than the posterior lobe (maximum width 154 mm).

The endoplastron is wider (EnW = 58 mm) than it is long (EnL = 45 mm) (Fig. 3). The epiplastral–hypoplastral suture is sigmoidal. The hypoplastra are the longest bony elements in the plastron (HyL = 105 mm). Of the epidermal scutes, the intergular is the most distinctive. It completely separates the gulars and penetrates deeply between the humerals. The humeral–humeral seam is only 15 mm long whereas the humerals have a maximum height of 87 mm. The longest scutes are the abdominal (A_1 = 105 mm), followed by the femoral scutes (F_1 = 95 mm), pectoral scutes (PL = 67 mm), anal scutes (AnL = 66 mm), intergular (IL = 62mm) and finally the humerals (HL = 15 mm).

The humeral–pectoral seam is sigmoidal, the most anterior sections being at the midline and at the extreme margins. The intergular has a maximum width of 26 mm but is only 19 mm wide along the anterior edge of the plastron. The gulars are small being only a little wider (GL = 28 mm) than the intergular. The intergular extends most of the way between the humerals. The intergular intrusion is longer than the gular length.

The carapace is large and flat along the ventral surface. The leading edge of the carapace is almost

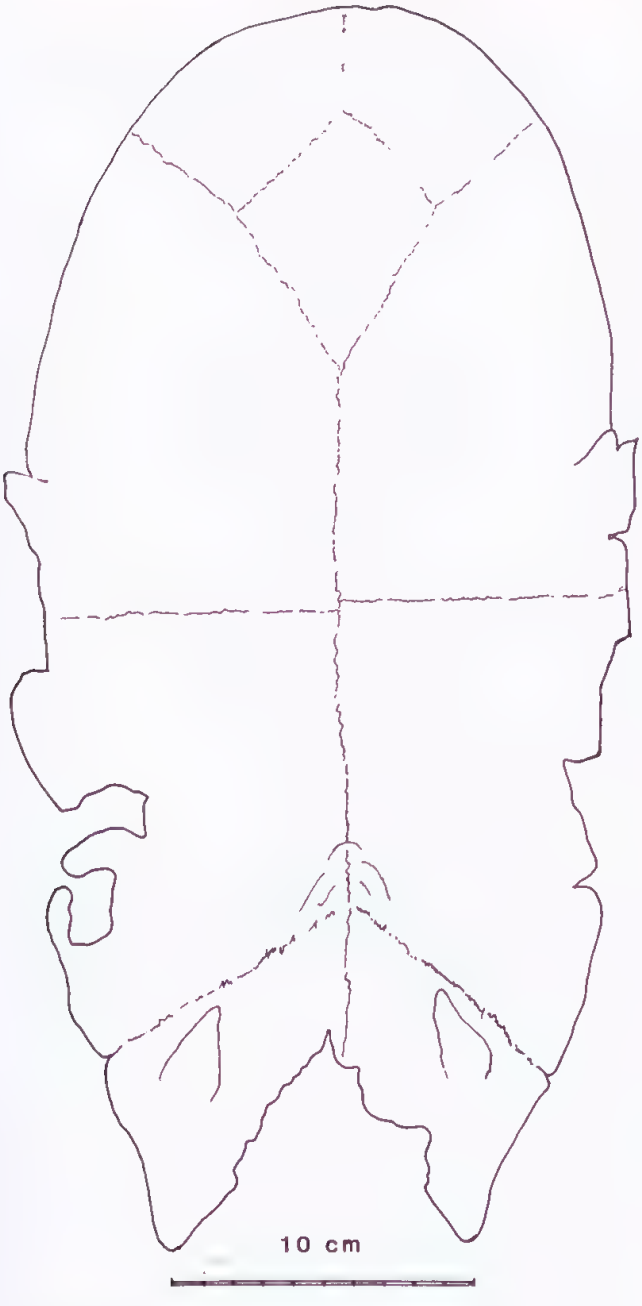

FIGURE 3. Internal view of plastron of *Emydura lavarackorum*.

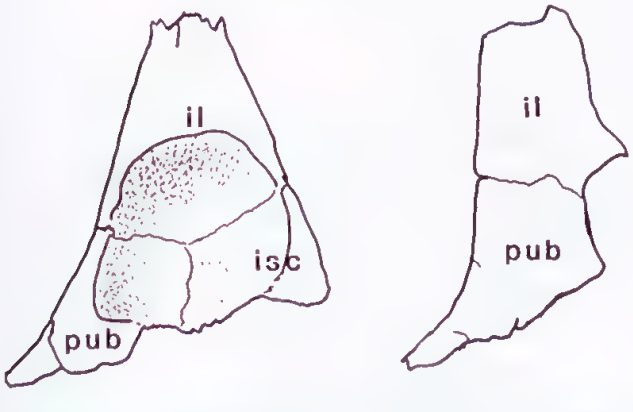

FIGURE 4. Acetabular view and lateral view of the left hip of *Emydura lavarackorum*.

straight and does not curve posteriorly until the suture line between the second and third marginal scutes. A precentral (nuchal) scute is absent. The broad anterior edge of the carapace is reflected by an expansion of the V_1 scute (maximum width 103 mm). This scute is almost twice as wide as the second vertebral scute (width 56 mm). V_1 (height 70 mm) is not as high as V_2 (height 87 mm). The third vertebral scute is incomplete but appears to be of similar proportions to the V_2 scute. The projections of the vertebral scutes between the costals is minimal. The first costal scute (C_1) is higher (95 mm) than C_2 (83 mm in height). It was not possible to measure the width of the costals.

The recess for the insertion of the anterior bridge strut on the undersurface of the carapace is steeply angled across the first pleural bone and is not in line with the raised process that forms the mid-pleural wall. The recess abuts the second peripheral bone and forms most of the base of the third peripheral (Fig 5). The dorsal fork of the transverse process on the first thoracic vertebra sweeps backwards to form the top of the mid-pleural wall.

A major section of the left pelvis comprising of the ischium, ilium and pubis was measured. The piece was 55 mm long and 20 mm wide at the ilial fracture. It was 35 mm wide at a position level with the acetabulum (which had a diameter of 25 mm).

The acetabulum is quite deep and is overhung by a pronounced upper ridge formed by the extension of the ilial ridge (Fig 4). The lower lip of the acetabulum has a much weaker rim formed a joining ridge continuous between the pubis and ischium.

Measurements (mm) of the holotype:

ACW = 210; V_1W =105; V_1H = 72; V_2W = 65; V_2H = 87; C_1H = 95; C_2H = 83; TPL = 390; APL = 110; BW = 115; PPL = 165; IW = 20; IH = 62; GW = 30; GL = 30; II = 36; HL = 15; PL = 67; AL = 105; FL = 95; AnL = 66; AW = 93; EpL = 30; EnH = 45; EnW = 58; HyL = 105.

Comparisons and discussion

The Riversleigh fossil turtle is placed in the Chelidae because of the evidence of pelvic fusion to the shell and the absence of mesoplastra and neural bones (Gaffney 1977).

Within the Chelidae, the Riversleigh turtle is placed in the genus *Emydura* on the basis of a recently identified synapomorphy. This feature relates to the insertion of the anterior bridge into

TABLE 1. Shell characteristics of Australian short-necked chelids.

Feature	*Rheodytes*	Alpha	*Elseya dentata*	*Elseya latisternum*	*Emydura kreffti*	*Emydura macquarii*	*Pseudemydura*
Relative Length of Anterior Plastron	60–70% of the length of the posterior plastron	66% of the length of the posterior plastron	80–90% of the length of the posterior plastron	82–95% of the length of the posterios plastron	75–88% of the length of the posterior plastron	75–85% of the length of the posterior plastron	45–65% of the length of the posterior plastron
Relative Width of Anterior Plastron	Narrower than the posterior plastron	Wider than posterior plastron	Narrower than the posterior plastron	Wider than the posterior plastron	Wider than the posterior plastron	Wider than the posterior plastron	Wider than the posterior plastron
Bridge Width	Narrow: shorter than the length of ant. plastron	Narrow: shorter than the length of ant. plastron	Broad: longer than the anterior plastron	Narrow: shorter than length of ant. plastron	Broad: longer than the anterior plastron	Broad: longer than length of ant. plastron	Broad: longer than length of ant. plastron
Bridge Buttresses	Pronounced inguinal and axillary buttressing	Pronounced inguinal and axillary buttressing	No raised buttressing	No raised buttressing	No raised buttressing	No raised buttressing	No raised buttressing
Shape of Recess for Anterior Bridge Struts	Recess in line with mid pleural wall	Recess in line with mid pleural wall .	Recess in line with mid pleural wall	Recess in line with mid pleural wall	Recess angled above mid pleural wall	Recess angled above mid pleural wall	Recess in line with mid pleural wall
Relative Width of Intergular	Narrower than the gulars	Narrower than the gulars	Narrower than the gulars	Wider than the the gulars	Narrower than the gulars	Narrower than the gulars	Wider than the gulars
Extent of Gular Penetration	Intergular penetrates 1/3 between humerals	Intergular penetrates half way between gulars	Intergular penetrates half way between humerals	Intergular penetrates half way between humerals	Virtually no separation of humerals by intergular	Intergular penetrates half way between the humerals	Intergular complete

the ventral surface of the carapace. The recess for the anterior bridge is angled steeply backwards to reach the raised process that forms a transverse wall across the floor of the first pleural bone. In the other chelid genera, the recess is itself transverse and so forms a near continuous line with the mid-pleural wall (Fig. 5). The Riversleigh *Emydura* has this derived characteristic.

Osteological comparisons (e.g. Gaffney 1977) of the shells and skulls of *Emydura* and *Elseya* have highlighted the great degree of similarity between these two genera. Current taxonomy (Obst 1986, Cogger 1993) recognises two species of *Elseya* and 6 species of *Emydura*. The diagnostic features that are used to identify the genera and species are features that include soft anatomy, skull ridges and plastral scute patterns. Legler (1985) and Georges and Adams (1993) have cast doubts about the validity of current concepts of these genera, especially *Elseya* which appears to be paraphyletic. On the basis of the carapacial synapomorphy identified in this paper *Emydura*, however, appears to be monophyletic.

The Riversleigh *Emydura* is a large turtle compared to other Australian chelids. It has a plastral length of 39 cm and hence would most likely have had a carapace length of approximately 41 cm. In comparison, the largest measured extant chelid is *Elseya dentata*. Cann (1986) has reported adults of this species with carapace lengths of up to 36.5 cm. The largest *Emydura* species is *E. macquarii* which may reach shell lengths of up to 40 cm (Cogger 1993).

In the extant Australian chelid species, the bridge typically occupies between 20 and 30% of the plastron length (Table 1). *Emydura macquarii* and *E. signata* have the narrowest bridge (20–23% of the plastron length) of all *Emydura* species. In contrast the bridge of *E. kreffti* is particularly broad and varies between 28 and 33% of the plastron length In the Riversleigh turtle, the bridge is wide (30% of the plastron length).

The bridge struts of the Riversleigh turtle are unusually thick. The anterior bridge struts are 2.15 cm wide at the base and almost 1cm wide in the middle. The largest comparative chelid specimen that was available for measurement was a deep-shelled snapper (*E. dentata* carapace length 28.5 cm, R40181). The anterior bridge strut of this animal was only half as massive.

Carapace shape varies in *Emydura*. Species such as *E. macquarii* and *E. signata* have broad, low domed carapaces that are expanded at the rear. In the range of shell shapes *E. kreffti* represents the other extreme and has a high domed carapace that is not expanded at the rear (Goode 1966). *E. lavarackorum* is intermediate in shell shape and has a carapace that is not evenly rounded.

In all species of *Emydura* the gular scutes of the plastron are completely divided by the intergular (Table 1). *Emydura* turtles also show partial separation of the humerals by the intergular, with the degree of separation being less than half of the mid-humeral length. Of the other Australian chelid genera, only in *Pseudemydura* does the intergular also completely divide the humerals. The intergular of *Elseya latisternum* produces the weakest separation of the humerals and barely intrudes between the humerals. *Emydura lavaracki* is most distinctive in this regard as the intergular deeply divides the humerals without completely separating them.

In the extant Australian *Emydura*, the arrangement of the pelvic bones around the acetabulum is similar. Here the ilium, ischium and

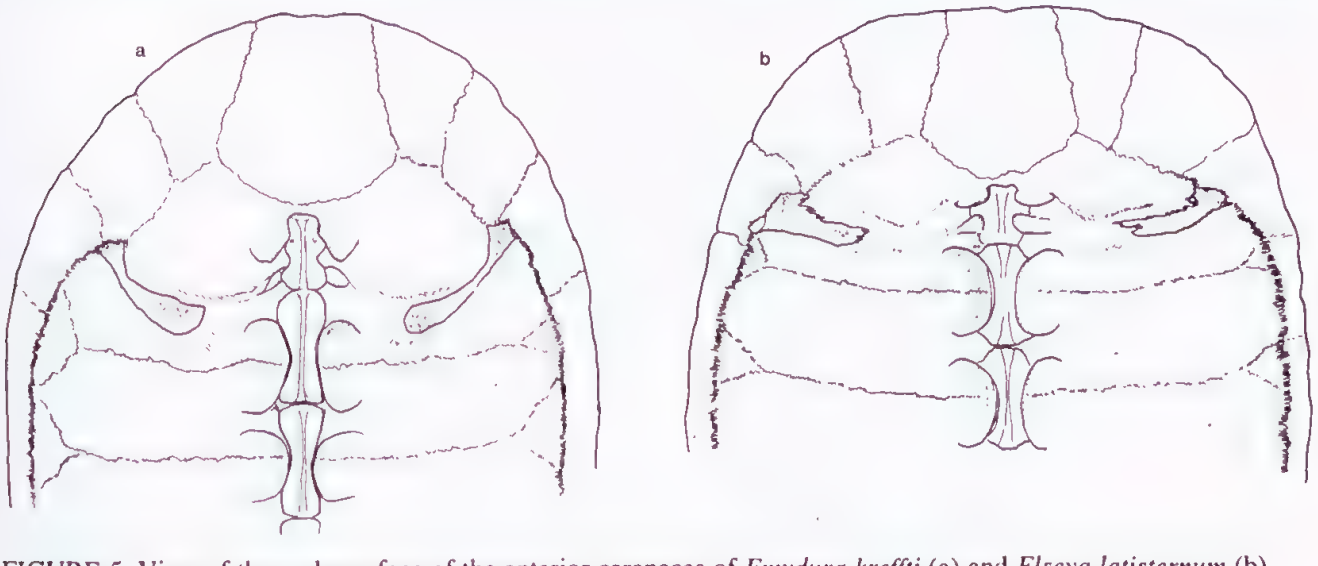

FIGURE 5. View of the undersurface of the anterior carapaces of *Emydura kreffti* (a) and *Elseya latisternum* (b).

pubis contribute almost equally to the composition of the acetabulum. This arrangement is also present in *Emydura lavarackorum*. In the extant species of *Emydura* the upper and lower rim of the acetabulum are equally protuberant. *E. lavaracki* is different in this regard as the upper lip of the acetabulum is more substantial than the lower lip. This means that the acetabulum is relatively deeper in this species.

The conventional guide for determining species within the genus *Emydura* is based on features of soft anatomy, shell shape and distribution (Cogger 1993). Other shell features have been used such as the relative length of the plastron compared to the carapace, the relative length of the anterior plastron compared to the posterior plastron and the relative width of the bridge (Goode 1966). *E. macquarii* has a plastron that is noticeably shorter than the carapace (80–85% of the carapace length). By way of contrast, *E. kreffti* has a longer plastron that ranges from 85–95% of the carapace length. Based on the shell reconstruction of *E. lavarackorum* the plastron appears to be about 95% of the length of the carapace. In some species of *Emydura*, such as *E. macquarii*, the anterior plastron is conspicuously shorter than the posterior plastron. In comparison, *E. kreffti* has anterior and posterior plastron segments that are almost equal in length. *E. lavarackorum* the anterior plastron is much shorter (67%) than the posterior plastron.

In view of the many evidently significant differences between the Riversleigh fossil species and any others referred to this genus, we have no hesitation in describing the fossil form as the new species *Emydura lavarackorum*.

Although we have placed this species in the genus *Emydura* on the basis of shell morphology it is apparent that it is not particularly closely related to any of the other species in this genus. In two respects, this Pleistocene chelid is unlike all Australian short-necked turtles: the massive expansion of the V_1 scute and the deep extension of the intergular between the humerals. In these features, the Riversleigh form more closely resembles the long-necked chelids. Further clarification of the intrafamilial affinities of the Riversleigh form may have to await discovery of cranial material.

Acknowledgments

We wish to acknowledge the vital financial support the Riversleigh Project has had from: the Australian Research Grant Scheme (Grant PG A3 851506P); the National Estates Scheme (Queensland); the Department of Environment and Arts; Wang Australia Pty Ltd; ICI Australia Pty Ltd; the Queensland Museum; the Australian Geographic Society; Mount Isa Mines Pty Ltd; and Surrey Beatty & Sons Pty Limited. Critical logistical support in the field and laboratory has been received from the Riversleigh Society, the Friends of Riversleigh, the Royal Australian Air Force, the Australian Defence Force, the Queensland National Parks and Wildlife Service, the Riversleigh Consortium (Riversleigh being a privately owned station), the Mount Isa Shire, the Burke Shire, the Northwest Queensland Tourism and Development Board, the Gulf Local Development Association, PROBE and many volunteer workers and colleagues including Dr Suzanne Hand and Henk Godthelp who helped to recover the holotype. Alan Rackham Snr and Alan Rackham Jnr discovered the Terrace Site in the first place. Among the volunteers who helped at the 1984 Riversleigh Expedition, special thanks are extended to Bruce Armitage, John Courtenay, Martin Dickson, Joy Dohle, Archie Daniels, Bernie Jennings, Leslie Hobbs, Bill Lockwood, Audrie and Harry Macintosh, Reg Markham, Melody Nixon, Ron Norman, Jim and Sue Lavarack, Brian, Bronwen and Dan O'Dwyer, Lazar Radanovich, Jim Ross, Mary Sandilands, Donald and Sue Scott-Orr, Jack Struber, Dr Steven Waite and Shirley Webster.

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FROGS FROM A PLIO-PLEISTOCENE SITE AT FLORAVILLE STATION, NORTHWEST QUEENSLAND

MICHAEL J. TYLER, HENK GODTHELP & MICHAEL ARCHER

TYLER, M. J., GODTHELP, H. & ARCHER, M. 1994. Frogs from a Plio-Pleistocene site at Floraville Station, northwest Queensland. *Rec. S. Aust. Mus.* **27**(2): 169–173.

Six frog ilia, mostly in good condition, have been recovered from riverine gravels on the western bank of the Leichhardt River, south of the Floraville Station Homestead at Floraville Station in northwest Queensland.

Three species of frogs are included: the extant species *Cyclorana cultripes* Parker, *C. platycephala* (Günther) and also *Limnodynastes* sp. cf. *L. tasmaniensis* Günther. They constitute the first fossil record of the fossorial genus *Cyclorana*, whilst the *Limnodynastes* species resembles closely material from earlier (Oligo-Miocene) sites at the nearby locality of Riversleigh Station.

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A characteristic of the frog fossil record in Australia is that most of the Tertiary sites are in the north of the continent, whereas the Quaternary sites are predominantly in the south (Tyler, 1989, in press; Tyler & Godthelp, 1993). Here we report an exception to the trend, for one of us (M. A.) recovered vertebrate material from an undated site in northwest Queensland considered to be Plio-Pleistocene. The site was named 5C in the M. A. notebook and consists of riverine gravels located on the western bank of the Leichhardt River south of the Floraville Station Homestead. Included are six anuran ilia representing three species.

Materials and methods

The ilia are deposited in the collection of the Queensland Museum, Brisbane. Methods of measurement and descriptive terminology follow Tyler (1976). Scanning electron micrographs were prepared with a Cambridge Autoscan Model 5250.

Systematics

Family HYLIDAE

Sub-family PELODRYADINAE

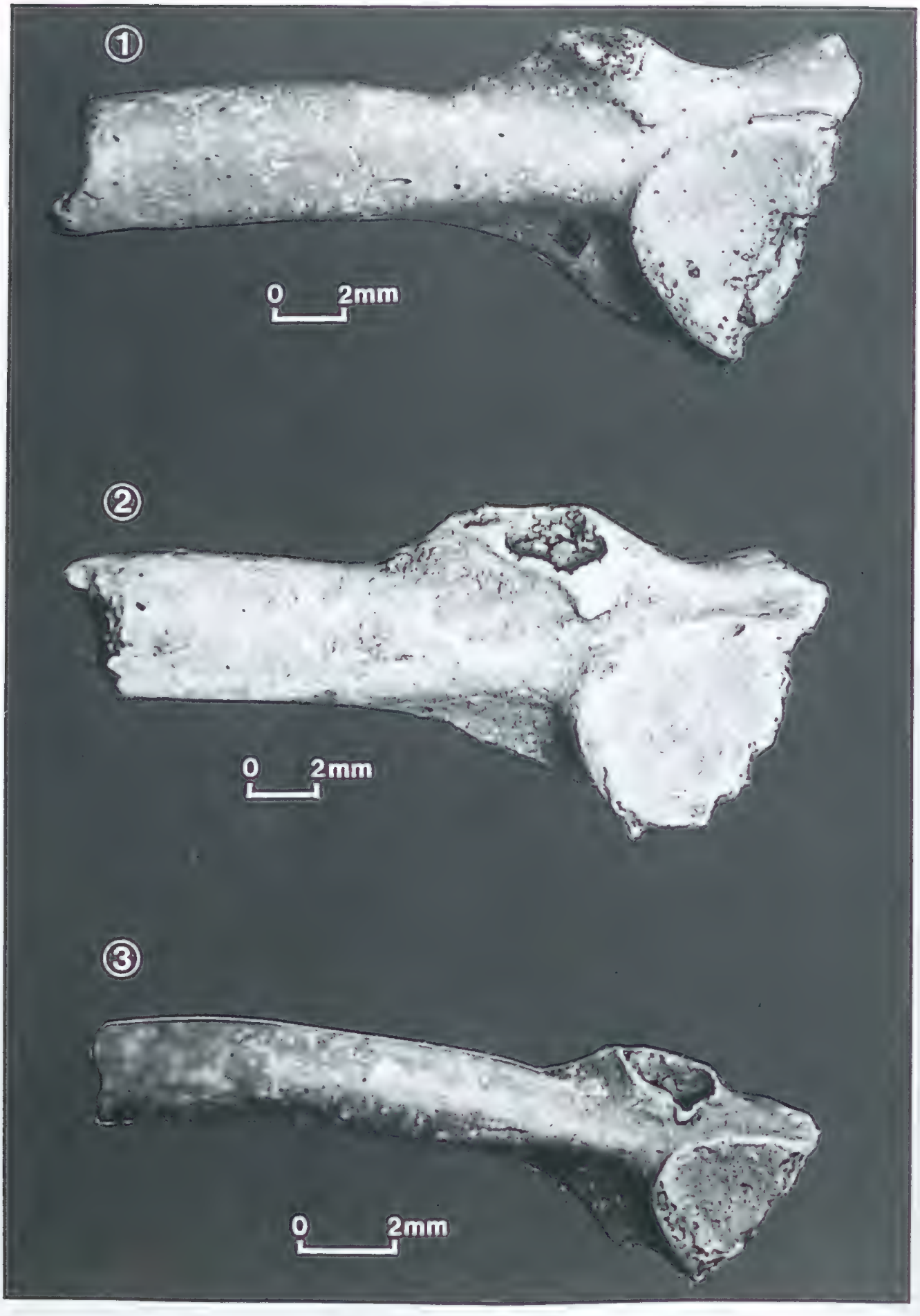
Genus *Cyclorana* Steindachner

The generic features of the pelvis of *Cyclorana* were described by Tyler (1976) based on the examination of the closely related taxa *C. australis* (Gray) and *C. novaehollandiae* Steindachner, and the more divergent *C. dahlii* (Boulenger) and *C. platycephala* (Günther). The only major difference in ilial structure noted amongst these species was the absence in *C. platycephala* of a narrow dorsal rim possessed by the others.

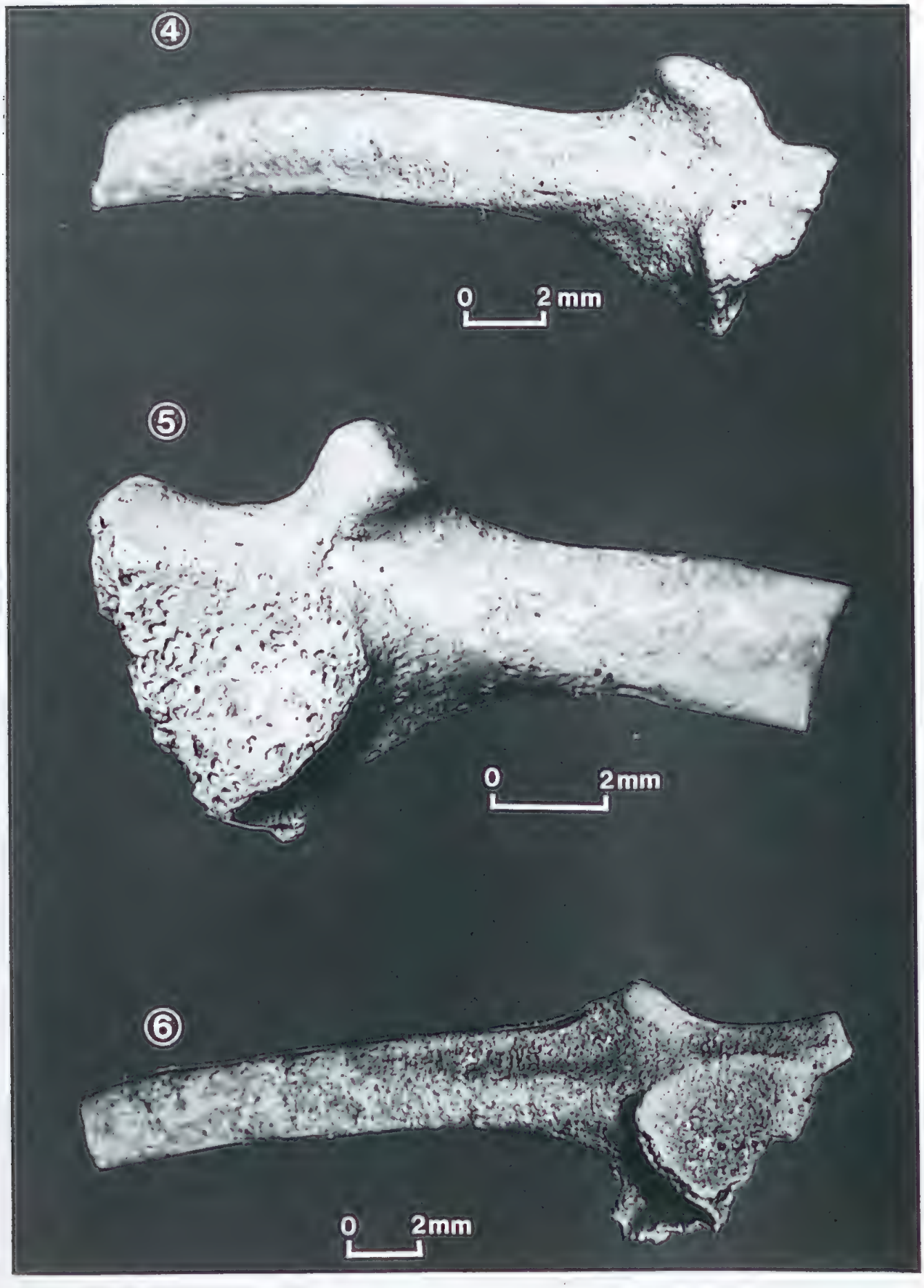
Subsequently *C. dahlii* was transferred from *Cyclorana* to the genus *Litoria* Tschudi by Tyler, Davies & King (1978). For that reason and because of access to all *Cyclorana* species except *C. manya*, it now is possible to redefine the ilial characteristics of *Cyclorana*.

The ilial shaft is long, slender and slightly curved, and in *C. australis* and *C. novaehollandiae* bears a narrow dorsal rim on the lateral surface, and a corresponding depression upon the medial surface. This rim and indentation is lacking in the remaining species. The acetabular rim is narrow and the fossa extensive.

The ventral acetabular expansion is gently rounded and the preacetabular zone is narrow. The dorsal acetabular expansion is well developed and has a gently curved anterior margin. There is a major dichotomy in the form of the dorsal protuberance: inconspicuous and laterally disposed in *C. australis* and *C. novaehollandiae*, but distinctly elevated as a very conspicuous feature in the remaining congeners.



FIGURES 1–3. *Cyclorana cultripes* Parker. 1: QM F 23023; 2: QM F 23024; 3: QM F 23029.



FIGURES 4–6. *Cyclorana* and *Limnodynastes*. 4: *Cyclorana platycephala* (Günther), QM F 23210; 5: *Cyclorana platycephala* (Günther), QM F 23025; 6: *Limnodynastes* sp. cf. *L. tasmaniensis* Günther, QM F 23022.

Cyclorana cultripes Parker
Figs 1–3

Material: QM F 23023, left ilium; F 23024 left ilium; F 23029 left ilium.

The ilial characteristics of *C. cultripes* have not been reported. The fossil material listed above conforms to ilia dissected from extant material principally in the unusual form of the dorsal prominence on the ilial shaft which is elongate, and extends medially over much of its length. As indicated in Figs 1–3 the dorsal prominence has a length equivalent to the diameter of the ilial portion of the acetabular fossa. In each of the fossils the lateral extremity of the dorsal prominence has been abraded.

Cyclorana platycephala (Günther)
Figs 4–5

Material: QM F 23210, left ilium; F 23025 right ilium.

In its overall habitus *C. platycephala* is the most divergent of all of the members of this genus. What sets it apart is the large flat head with small eyes protuding from the dorsal surface, and the extensively (usually fully) webbed toes. The ilium is equally distinctive by virtue of the highly developed dorsal prominence, which rises high above the ilial shaft in an almost cylindrical form.

Family LEPTODACTYLIDAE
Sub-family LIMNODYNASTINAE

Genus *Limnodynastes* Fitzinger

Limnodynastes sp. cf. *L. tasmaniensis* Günther
Fig. 6

Material: QM F 23022, left ilium.

Amongst the members of the genus *Limnodynastes* the features that are unique to this species are the protuberant nature of the sub-acetabular zone, the lateral groove upon the ilial shaft, and the anteriorly inclined dorsal prominence and dorsal protuberance. These features are shared by modern representatives of *Limnodynastes tasmaniensis*, and particularly specimens reported from Oligo-Miocene sites at Riversleigh Station in northwest Queensland

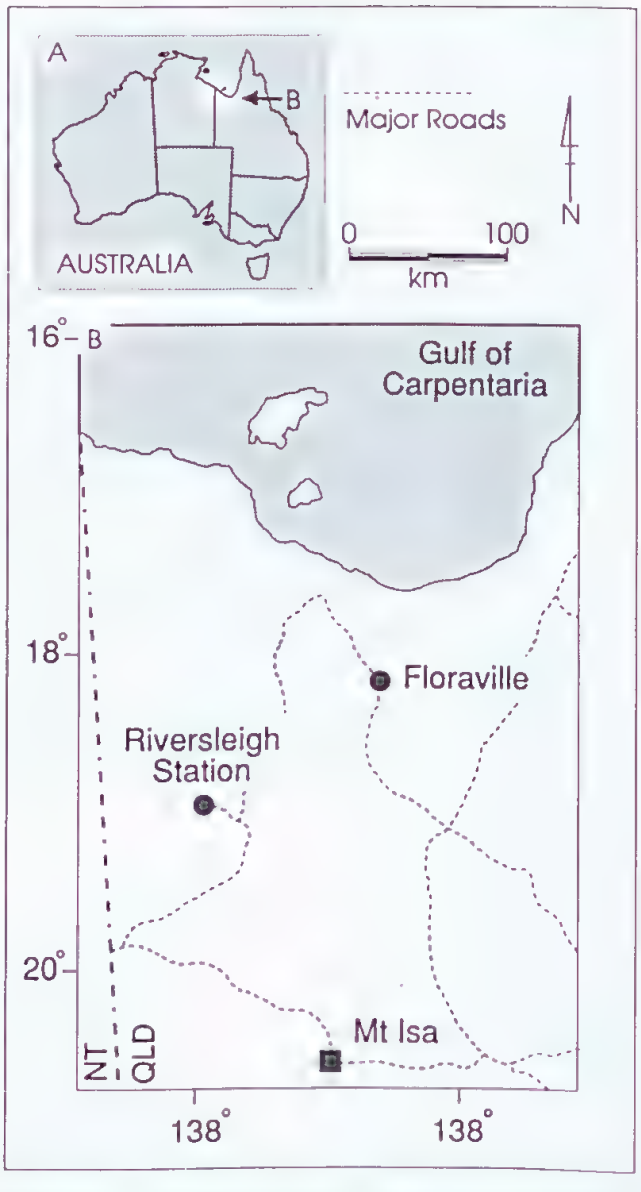


FIGURE 7. Location of Floraville Station and Riversleigh Station, Queensland.

(Tyler, 1990a). The location of Floraville and Riversleigh Stations is shown in Fig. 7.

Discussion

This small assemblage of frogs from the Tertiary of northwest Queensland is significant for several reasons. Firstly because of the presence of two extant species of *Cyclorana*, being the first fossil record of this genus. Neither species has been reported as far northeast. In the case of *C. platycephala* every voucher specimen known throughout Australia until January 1990 was plotted by Tyler (1990b). Floraville Station is just beyond its known modern geographic range. The presence of *C. cultripes* at Floraville Station

similarly has not been recorded, but it is common at similar latitudes and may be assumed possibly to exist there today; there has been minimal collecting activity in the area.

The presence of *Limnodynastes* sp. cf. *L. tasmaniensis* in this collection is intriguing. The modern species has an extensive distribution throughout eastern and southeastern Australia, and was introduced to Kununurra in the Kimberley Division of northern Western Australia (Martin & Tyler 1978). More recently a second isolated population has been located at Newry Station in the Northern Territory (Tyler, Watson, & Davies, 1983). The interpretation of the presence of the species so far from its known geographic range is that it was introduced there. The location of comparable material at mid-Miocene sites at Riversleigh Station in northwest Queensland (Tyler 1990a), and its presence at Floraville Station in the Plio-Pleistocene collectively suggest a far longer duration of existence in northern Australia of an ancestral form resembling the modern. Clearly it is possible that the extant Kununurra (WA) and Newry Station (NT) populations should be explored as possible relics, rather than recent introductions.

The mammal fauna at the site is dominated by several taxa of as yet undescribed rodents. There is also a high diversity of marsupials, with some extant genera. The sediments are undated but are suggested to be Plio-Pleistocene by Archer (1982, 1984).

Acknowledgments

We are grateful to Mr and Mrs Camp for permission for M. A. to work on Floraville Station. The field work was supported by R. E. Lemley, the Queensland Museum and the Australian Research Grants Committee. Comparative studies were aided by S. Bryars and supported by the Australian Research Council. The S.E.M. photographs were prepared by Stuart Mclure of the CSIRO Division of Soils, Adelaide.

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FORM AND FUNCTION IN SCALES OF *LIGULALEPIS TOOMBSI* SCHULTZE, A PALAEONISCOID FROM THE EARLY DEVONIAN OF AUSTRALIA

CAROLE BURROW

BURROW, C. 1994. Form and function in scales of *Ligulalepis toombsi* Schultze, a palaeoniscoid from the early Devonian of Australia. *Rec. S. Aust. Mus.* **27**(2): 175–185.

A variety of isolated scales and lepidotrichia from the Early Devonian of New South Wales is referred to the palaeoniscoid *Ligulalepis toombsi* Schultze 1968, to date known only by isolated scales. Scales of various forms are attributed to specific regions of the body, on the basis of comparisons with articulated Palaeozoic palaeoniscoids. Mobility of scales in the forward flank region appears to have been constrained by a prominent process projecting from the rostro-dorsal corner, in addition to the peg, socket and keel of typical palaeoniscoid scales. Such complex interlocking of the scales implies that the body of *Ligulalepis toombsi* was relatively inflexible. Some suggestions are offered regarding the possible mode of locomotion.

This is a contribution to IGCP 328: Palaeozoic Microvertebrates.

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Manuscript received 21 April 1993.

Ligulalepis toombsi Schultze 1968 is the only palaeoniscoid so far described from Australian sediments older than the Late Devonian. Although no whole, or even partially articulated, specimens have yet been discovered, *Ligulalepis* scales are distinctive and widespread in microvertebrate assemblages from marine Lower Devonian deposits from south eastern, and possibly western, Australia.

Scales of *Ligulalepis toombsi* were first described by Schultze (1968) from the lower part of the Murrumbidgee Group of Taemas, NSW, in greatest abundance from the *Spinella yassensis* Limestone Member of early Emsian age (probable conodont zone *dehiscens* or *gronbergi* – Campbell and Barwick 1988, Talent 1989). *Ligulalepis toombsi* scales were also reported by Giffin (1980) in a diverse microvertebrate assemblage from the Receptaculites Limestone, a lithic unit some 270 to 400 metres above the *Spinella yassensis* Limestone, and dated as mid-Emsian (probable conodont zone *inversus–laticostatus*). In their checklist of Australian fossil fish, Long and Turner (1984) listed other Australian occurrences of *Ligulalepis toombsi* (see Fig. 1a): the Broken River Group, Queensland, Early Devonian sites in New South Wales, and the Thangoo Calcarenite of the Canning Basin, Western Australia (a single scale, identified as cf. *Ligulalepis*, Turner *et al.*, 1981). Scales of a second species, *L. yunnanensis* Wang and Dong 1989, have been reported from the Late Silurian of China. Wang and Dong, in their description of this species (1989: 203), state that the scale peg, socket, and ligula are absent. Schultze (1968) includes these three features in his generic diagnosis, and so the affinities of *L. yunnanensis* are open to question.

In Schultze's description of *L. toombsi*, the species is not allocated to a family but is left in the 'bucket' grouping, the palaeonisciforms. There is currently no satisfactory classification of the palaeonisciforms (Schultze & Bardack 1987), and the terms palaeonisciform, palaeoniscoid and palaeoniscid are often used interchangeably. Even within the family Palaeoniscidae, genera that are included by some workers have been placed in entirely different families and even different orders by other workers. The term 'palaeoniscid' can be particularly confusing: it is sometimes used in referring to members of the family Palaeoniscidae (e.g. Esin 1990), or of the order Palaeoniscida (e.g. Moy-Thomas & Miles 1971), or of the superorder Palaeonisci and the order Palaeoniscidae (Kazentseva 1964). In this paper, the term 'palaeoniscoid' refers to fishes of the order Palaeoniscida exclusive of the deep-bodied platysomoids. As it is so difficult to categorise articulated specimens, it is understandable that a genus such as *Ligulalepis*, which is known only from isolated scales, should have been identified no more closely than 'palaeoniscoid'.

This paper describes several new types of *Ligulalepis* scales from the Early Devonian of NSW. *Ligulalepis* scales of various forms may be attributed to particular regions of the body, following the pattern of squamation described by

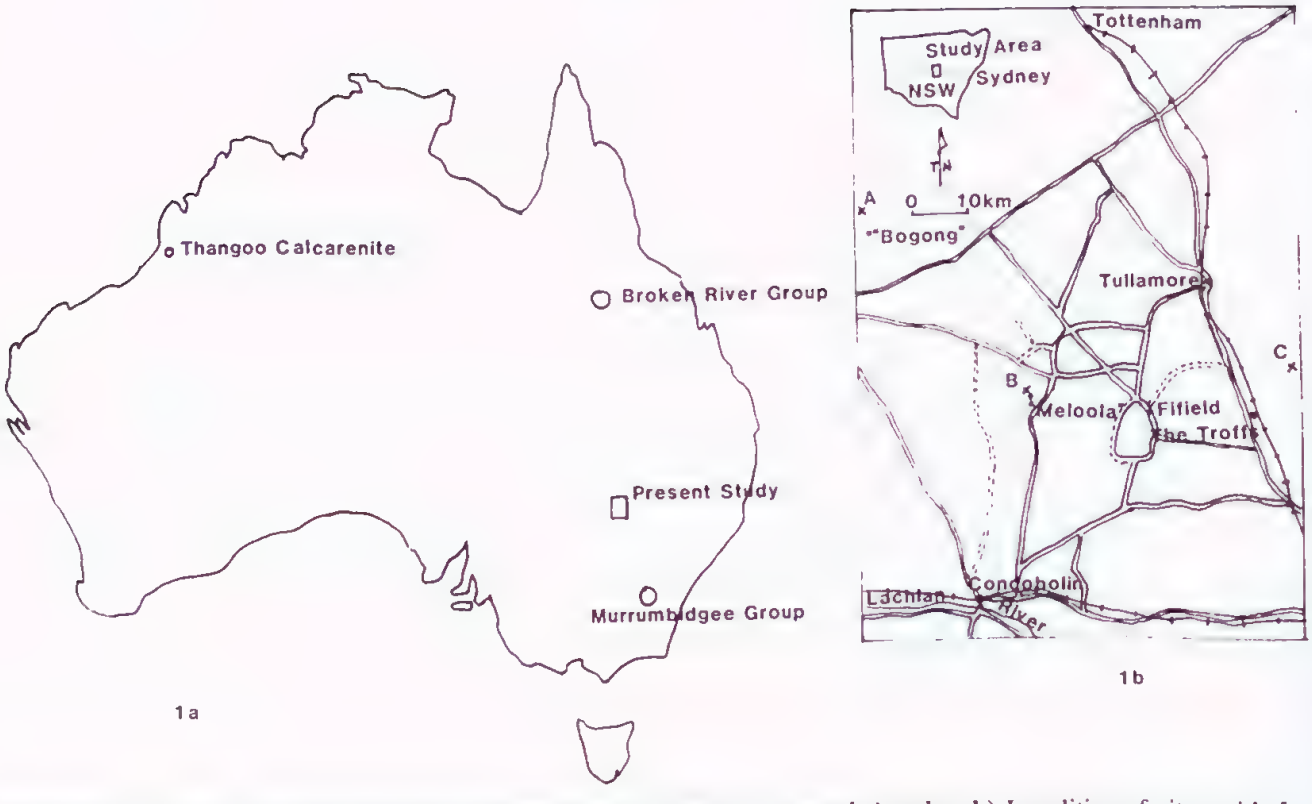


FIGURE 1. **a)** Map of Australia depicting known sites of *Ligulalepis toombsi* scales. **b)** Localities of sites with *L. toombsi* scales in study – Locality A: sites C091, C092, C624, C625. B: sites C600, C608. C: site C287. Position of sites based on Australian Topographical Map Series 1:250 000 Narromine and Nymagee. Map adapted from Pickett and McClatchie (1991: Fig.1).

TABLE 1. Distribution of scale types at different sites studied

Sites	T1	T2	T3	T4	T5	T6	T7	T8	T9
Trundle Beds Site C287(7 br + 5 lepidotrichia)	1L 4R	2L	5L 3R	1L	 1R	1	1L 1R	1L 2R	0
Mineral Hill Site C625(34 br)	5L 5R	5L 2R	3L 3R	2L 1R	1L 2R	2	1L	1L	0
Mineral Hill Site C092(7 br)	0	0	 2R	0	0	0	0	0	0
Mineral Hill Site C624	0	0	0	0	0	0	0	0	1L
Mineral Hill Site C628	0	 1R	1L	0	0	0	0	0	0
Mineal Hill Site C091	0	1L	0	0	0	0	0	0	0
Jerula Formation Site C600 – only 2 broken scales									

T=Type, L=Left, R=Right, br=broken.

Esin (1990) in the Permian palaeoniscid *Amblypterina costata* Eichwald.

Material

The study is based on 67 complete scales which are classifiable into 9 types, 50 pieces of scales, and 5 lepidotrichia. In addition, there are several pieces of dermal bone, bearing the chevron pattern of ornament characteristic of ganoid scales. Scales described in this paper came from residue limestone samples treated with acetic acid by Dr John Pickett (Geological Survey NSW) in searching for conodonts. The parent sites are in the Gleninga Formation of the Mineral Hill Group, Trundle Beds of the Trundle Group, and the Jerula Formation; all being in the Murda Syncline of western NSW, of *pesavis* and/or *sulcatus* conodont zones (Pickett 1992, Pickett & McClatchie 1991; see Fig. 1b). Table 1 details the distribution of scale types for the various localities; MMMC = Fossil Collection of the Mining and Mineralogy Museum, Sydney.

Scales of *Ligulalepis toombsi*

Schultze (1968) attributed four scale forms to *Ligulalepis toombsi*. Of these, the scale selected as holotype differed from all known palaeoniscoid scales in having its rostro-dorsal corner developed into a prominent tongue-shaped projection (described as 'löffelformig', or spoon-shaped, by Schultze 1968: 346; see Figs 2,3). In nominating a scale as a holotype, it is conventional and appropriate to choose an example from 'the anterior and middle parts of the lateral surface of the fish body on which the majority of morphological features are distinctly manifested' (Esin 1990: 93). In the case of palaeoniscoids, scales from other areas of the body may be referred to the same species by virtue of qualitative features – the form of the anterior margin of the

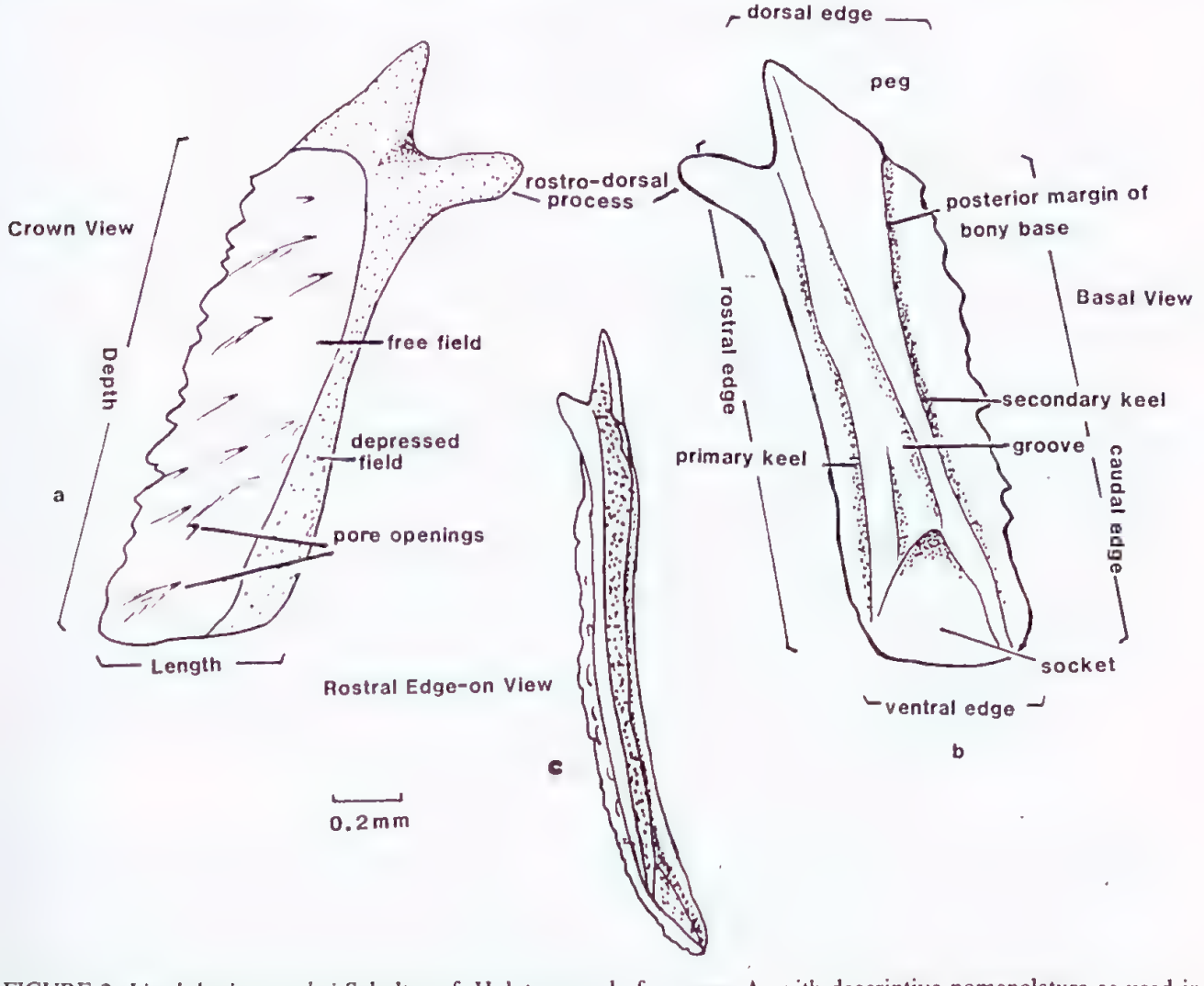


FIGURE 2. *Ligulalepis toombsi* Schultze cf. Holotype scale from area A, with descriptive nomenclature as used in text – **a**, crown view. **b**, basal view. **c**, rostral edge-on view.

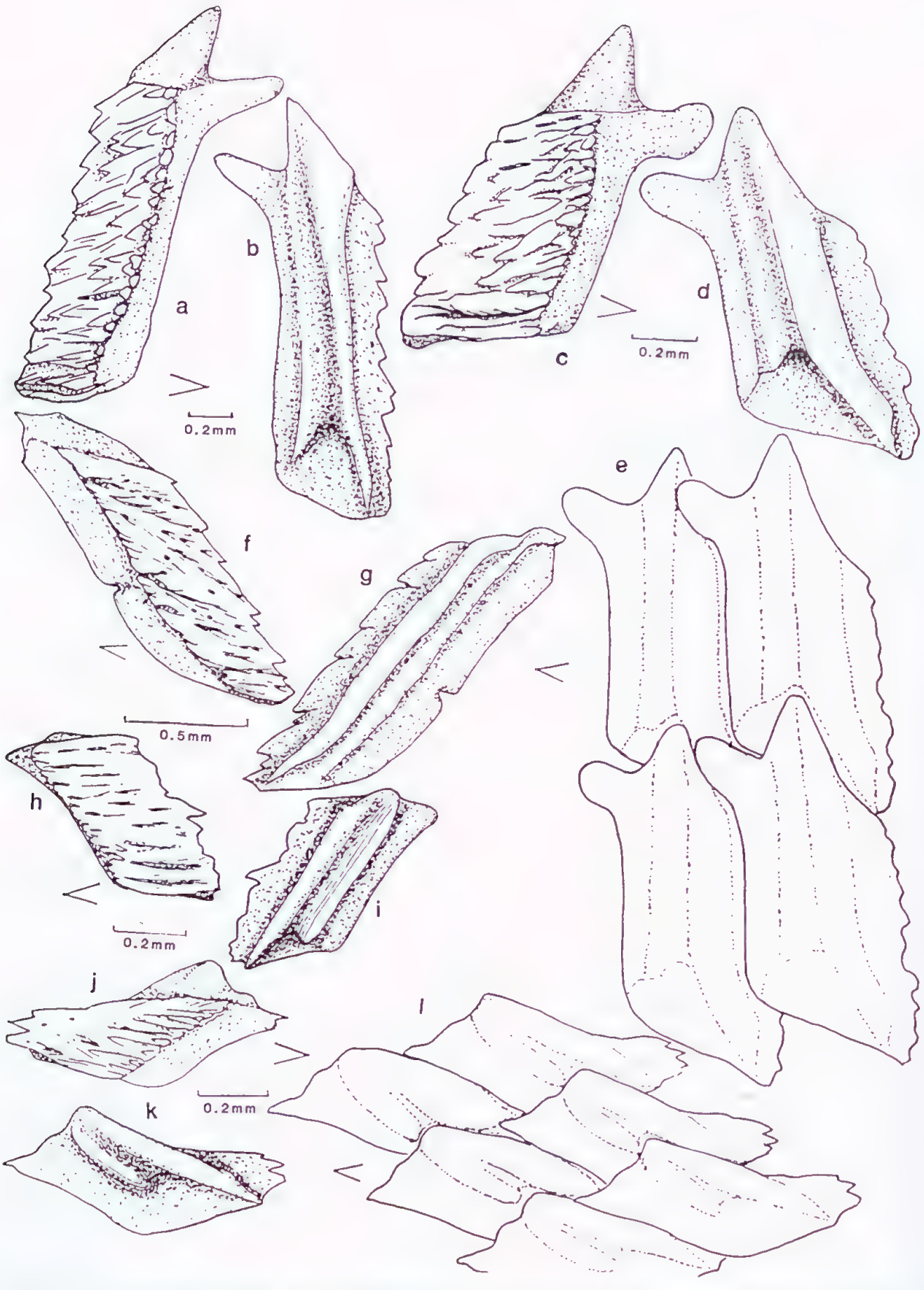


FIGURE 3. *L. toombsi* scales from: The mid-flank region of area A/B: **a**, crown view; **b**, basal view (ref. no. MMMC01926). Area B: **c**, crown view; **d**, basal view; **e**, conjectured basal view of interlocking adjacent scales (ref. no. MMMC01927). Area A, from region immediately behind the shoulder girdle and on the lateral line (note indent on anterior margin of scale): **f**, crown view; **g**, basal view (ref. no. MMMC01928). Area B/C: **h**, crown view; **i**, basal view (ref. no. MMMC01929). Area F: **j**, crown view; **k**, basal view; **l**, basal view of interlocking adjacent scales (ref. no. MMMC01930).

free field, the denticulation of the caudal margin of the scale, and detail of the sculptured ornament. These features were described for *L. toombsi* by Schultze (1968), as follows: anterior margin of the free field has an ornament of small knobs, with main ornament cover extending behind them; posterior margin serrated; numerous pores scattered over the ganoine surface; free field exhibits the chevron pattern typical of ganoine scales.

This study reveals considerable variation in the shape of the rostro-dorsal process, from tongue-shaped to pennant-shaped. Consequently, the term 'spoon-shaped' may be too narrow a description; in this paper it is described merely as the 'rostro-dorsal process'. About 22% of scales possess this process. Scales of *Ligulalepis yunnanensis*, as illustrated by Wang and Dong (1989), appear to lack this process, though this is possibly an effect of breakage (G. Young, pers. comm.).

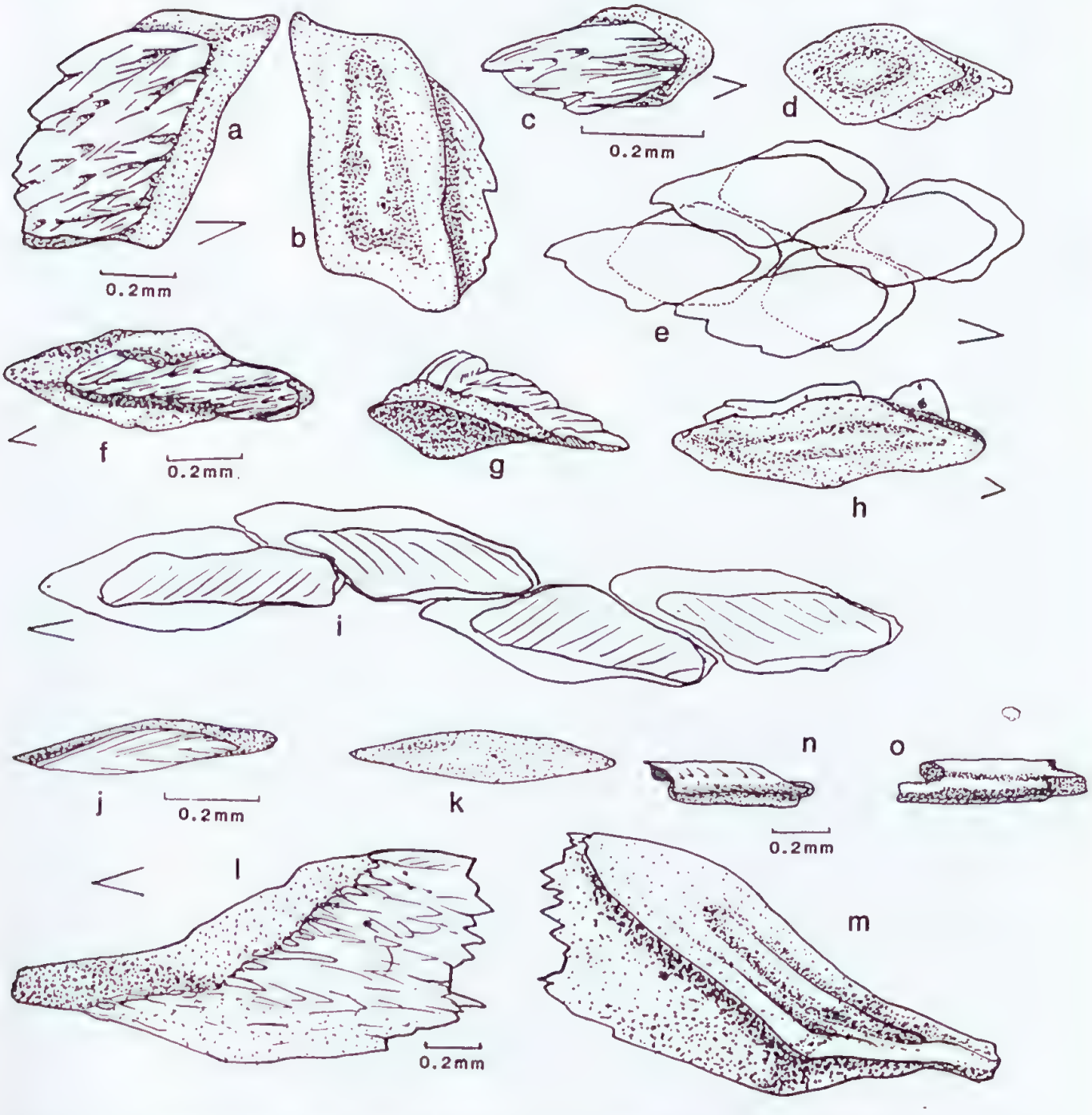
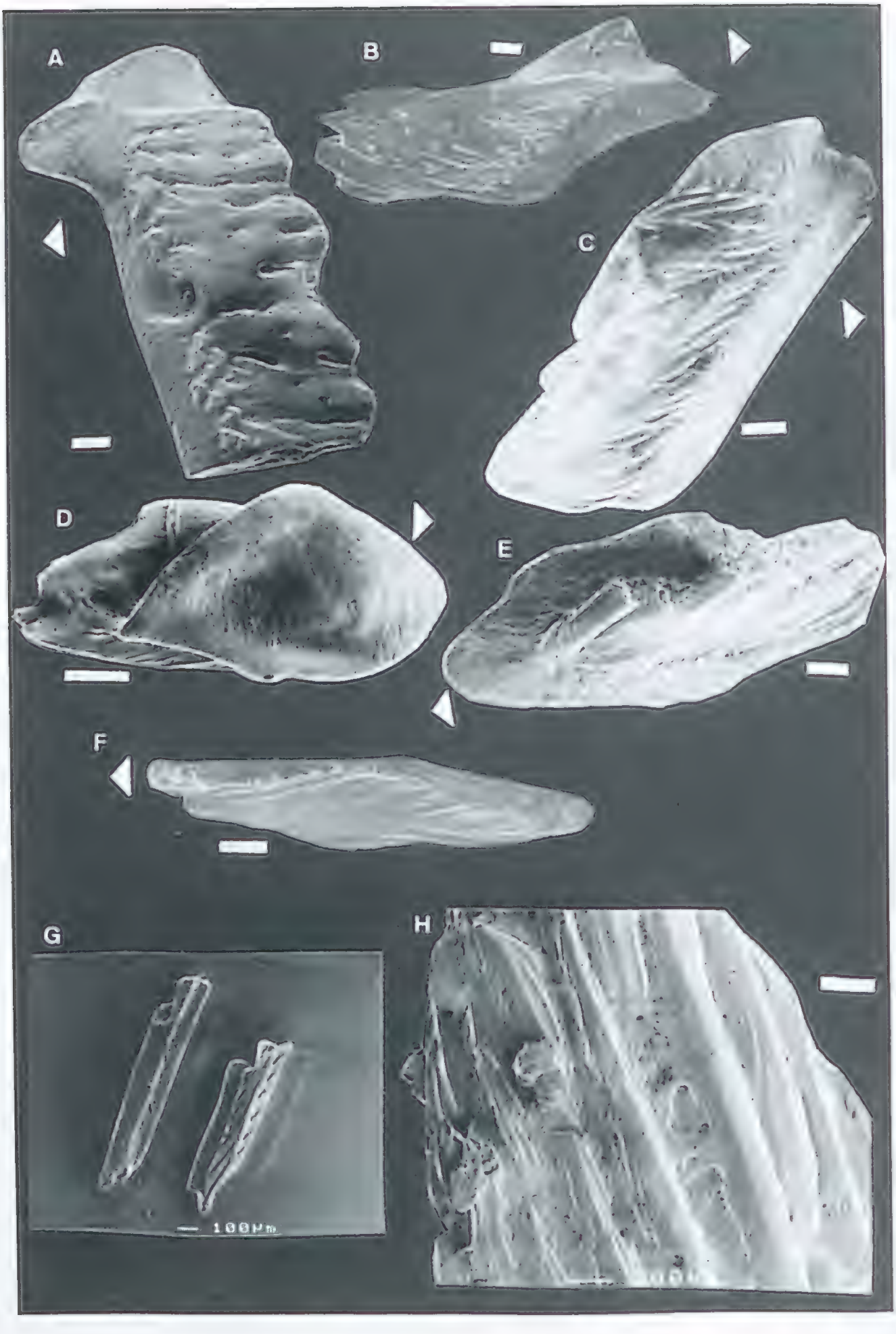


FIGURE 4. *L. toombsi* scales from: Area E: **a**, crown view; **b**, basal view (ref. no. MMMC01931). Area G/H: **c**, crown view; **d**, basal view; **e**, basal view of interlocking adjacent scales (ref. no. MMMC01932). Central ridge line – fulcral scale: **f**, crown view; **g**, lateral view; **h**, basal view; **i**, crown view of adjacent scales (ref. no. MMMC01937). Area D: **j**, crown view; **k**, basal view (ref. no. MMMC01933). Area B/F: note dorso-caudal/ventro-rostral orientation – **l**, crown view; **m**, basal view (ref. no. MMMC01939). Lepidotrichial scale: **n**, crown view; **o**, basal view (ref. no. MMMC01934).


A
B
C
D
E
F
G
100µm
H

Schultze (1968) stated that the holotype scale is from the anterior half of the body. The height to length ratio of the scales is maximal for each row at the centre of the flank. By analogy with scales on articulated specimens of other Palaeozoic palaeoniscoids (e.g. Gross 1953, Gardiner 1984, Stamberg 1989, Bürgin 1990, Esin 1990), nearly all overlapping scales in this study would have been oriented on the fish's body in rows directed from rostro-dorsal to caudo-ventral, except for scales from the latero-ventral angle.

Descriptions

Nine types of scales are attributed to *L. toombsi*, together with lepidotrichia. Descriptive terminology (see Fig. 3) follows Schultze (1968) and Esin (1990).

Type 1 (Figs 3a–e, 5a)

Scales are roughly rhomboidal, with a straight anterior margin except for the rostro-dorsal process. The dorsal peg is high with a pointed apex, matched by a ventral deep triangular socket. Primary and secondary keels are both well developed (as in Fig. 3). The ornamented free-field extends about two-thirds the length of the scale, and overhangs the caudal margin of the scale's bony base. The depth:length ratio varies between approximately 3/1 and 3/2 (excluding peg and flange). Rarely, these scales may have pores for the lateral line canal. Scale ornament resembles that described in the holotype.

Type 2 (Figs 3f, g)

Scales generally similar in shape to those of type 1, but lacking a rostro-dorsal process. The dorsal peg and ventral socket are very weakly developed. Primary and secondary keels are prominent. The length of the unornamented depressed field is about one-third to one-quarter of scale length on the rostral margin, and from one-eighth to one-quarter the depth of the scale, on the dorsal margin. The depth:length ratio varies between approximately 3/1 and 2/1. Scale ornament resembles that of the holotype, though lacking the triangular "knobs" along the rostral margin of the free field.

Type 3 (Figs. 3h,i)

Scales of roughly rhomboidal form, with a straight anterior margin, and a small rostro-dorsal process. The dorsal peg and socket are weakly developed, whereas the primary and secondary keels are pronounced. The length of the unornamented depressed field is negligible, on both the anterior and dorsal margins. The depth:length ratio is about 2/1, and scale ornament resembles that of type 2.

Type 4 (Figs 3j–l, 5b)

Scales of skewed, roughly lozenge-shaped, outline, with an attenuated and sharply pointed rostro-dorsal corner. The peg and socket are present and very broad-based. The keels are parallel to the anterior margin of the scale, which is oriented obliquely (rostro-dorsal to caudo-ventral) relative to the horizontal ornament of the scale. The depressed field is about one-quarter the length of the scale, and the depth:length ratio is about 1/2. Ornament resembles that of the holotype, including the "knobs" along the rostral margin of the free field.

Type 5 (Figs 4a,b, 5c)

Scales of rhomboidal shape, without peg and socket. There are no keels, but the base of the scale has a dark central swelling. The depressed field on the dorsal and rostral margins is about one-quarter to one-fifth the length of the scale. The scales are slightly deeper than long, and their ornament is typical, aside from (like types 2 and 3) lacking the "knobs" along the rostral margin of the free field.

Type 6 (Figs 4c–e, 5d)

Almond-shaped to diamond-shaped scales. Peg, socket and keels are all lacking, but the base of the scale has a dark central swelling. The depressed field extends around the dorsal, rostral and ventral margins. The depth:length ratio is about 2/5. The ornamented surface extends to a point overhanging the caudal edge of the base. Scales lack ornament 'knobs' along the margins of the free field.

Type 7 (Figs 4f–i, 5e)

Scales of sub-rhomboidal form with a

FIGURE 5. Ligulalepis toombsi scales – (scale bar = 0.1mm) – **a**, Broken type 1, with large lateral line pore opening (ref. no. MMMC01938); **b**, Crown view, type 4 (ref. no. MMMC01930); **c**, Crown view, type 5 (ref. no. MMMC01935); **d**, Basal view, type 6 (ref. no. MMMC01932); **e**, Crown view, type 7 (ref. no. MMMC01937); **f**, Crown view, type 8 (ref. no. MMMC01934); **g**, 2 lepidotrichia: basal view (left) and lateral/crown view (right) (ref. no. MMMC01936); **h**, Fragment of dermal bone, showing chevron pattern.

transversely arched base. Peg, socket and keels are absent, but once again the base has a slight dark swelling located centrally. The depressed field extends along the dorsal, rostral and ventral margins. Ornament resembles that in scales of type 6, but raised at approximately 60° from the base and pointing dorso-caudally.

Type 8 (Figs 4j,k, 5f)

Narrow scales of lenticular outline. There are no pegs, sockets or keels, and the base is of uniform thickness. The depressed field extends from the rostral point dorsally to the caudal point, but is very narrow. The depth:length ratio varies from about 1/3 to 1/6. The ornamented surface is almost smooth, aside from a few shallow striations, and does not form an overhang.

Type 9 (Figs 4l,m)

Scales of 'bent' rhomboidal form, without peg or socket. There is a primary keel and a weak secondary keel. The depressed field is about a third the length of the scale. The depth:length ratio is about 2/1, and the long axis is oriented in a dorso-caudal to rostro-ventral direction. The ornament is typical, though it is noticeably more worn on the ventral half; it extends beyond the caudal margin of the scale base.

Lepidotrichia (Figs 4n,o)

These have a long, narrow 'bread-loaf' shape, with a longitudinal furrow in the middle of each side. There is a central peg and socket on some lepidotrichia, of the full thickness of the scale, and a groove running between these on the base of the scale. The lepidotrichia range in length from about 0.6mm to 1.0mm, and their width is about 0.1mm. The flat upper surface is relatively smooth, though pores are present and the surface is lightly striated. In contrast to the body scales, the ornament may extend onto the peg. The 'unnamed palaeoniscoid scales' illustrated by Giffin (1980, Fig. 11) appear to be examples of lepidotrichia from *L. toombsi*.

Discussion

Scale variation according to body area

Having categorised the scales into these different types, the question now is – from which sections of the body might they have come? Morphology of scales is known to vary in consistent fashion from area to area of the body in articulated specimens of palaeoniscoids (Gross 1953, Gardiner 1984, Long 1988, Esin 1990).

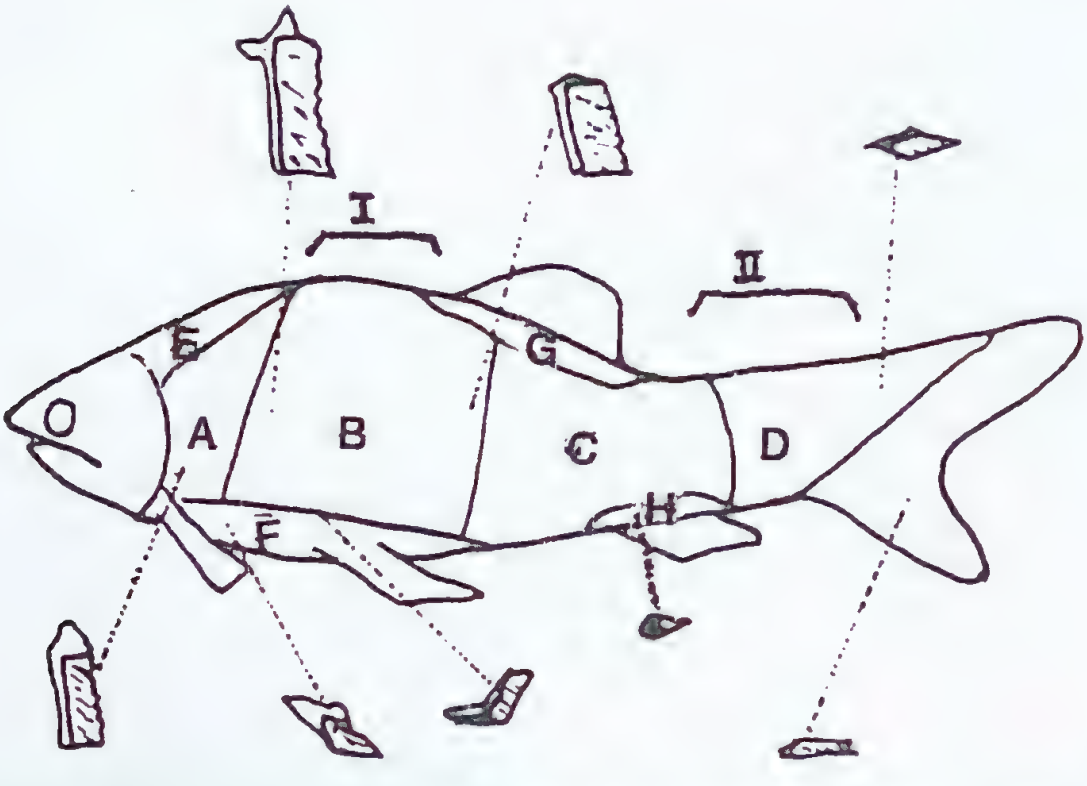


FIGURE 6. Diagrammatic outline of fusiform palaeoniscoid fish, showing distribution of major areas with morphologically distinct scales. **a**, area behind pectoral girdle; **b**, front half of flank; **c**, rear half of flank; **d**, tail (anterior to fin); **e**, in front of dorsal fin; **f**, ventral; **g**, surrounding base of dorsal fin; **h**, surrounding base of anal fin I & II, dorsal unpaired scale rows.

Consequently nine types of scales here described for *L. toombsi* may be assigned to specific areas of the body. The following designations are modelled on the scheme of variation described by Esin (1990) for *Amblypterina costata* Eichwald (see Fig. 6).

There is a decrease in the depth of scales from area A to area D, and from the median line of the fish to its dorsal and ventral margins. Thus the scales with greatest depth/length ratio should be assigned to area A. However, the first row of scales behind the shoulder girdle would not include forms depicted in Fig. 3, with their rostrally directed process, and it is for this reason Schultze (1968) assigned scales of type 2 to the area immediately behind the shoulder girdle. The scales would be expected to be well articulated, being in a relatively inflexible area of the body; scales of type 2 fit the criteria for scales along the rostral margin of area A, overlapping scales of type 1.

Scales of type 1 probably came from areas A and B, overlapping type 3 scales towards the B/C margin.

Scales in area C would not be expected to be highly articulated with each other, as interlocking devices (keels, pegs, sockets and, in the case of *L. toombsi*, rostro-dorsal processes) are weakly developed or absent on scales from more flexible areas of the body (Esin 1990). Scales of type 3 best fit the criteria exhibited by scales of this moderately flexible area in articulated palaeoniscoids.

Scales in the flexible area D lack articulations and are non-imbricating. Scales of type 8 would seem to fit here, becoming more elongated towards the tail fin.

Scales from area E are expected to have a broad low peg, with keels being weakly developed or absent, and a wide depressed field (Esin 1990). Scales of type 5 match these criteria best. Although they lack a peg, they are of a shape intermediate between that of scales of type 2 and type 7.

With regard to area F, the length of the wholly ventral scales of Palaeozoic palaeoniscoids described to date is invariably greater than their height, and they have poorly developed pegs and sockets, with an extended rostro-dorsal corner and a wide rostral depressed field, for secure anchoring in the skin. Scales of type 4 come from this area. Schultze (1968: Plate 1, figs 6a,b) stated that such scales were definitely from the ventral region. Scales of type 9, with a bent shape and worn ornament on the lower half must surely have come from the flank/ventral angle of the body. These were the only scales to have a rostro-ventral to dorso-caudal orientation, indicating a ventro-lateral scale row directional inversion.

Scales at the base of the fins are expected to be small relative to neighbouring scales, and to show bilateral symmetry (Esin 1990). Scales of type 6 fit these criteria, and by comparison with scales figured in Esin (1990) they most likely came from the base of one of the paired fins (areas G and/or H).

Scales of type 7 are probably ridge or fulcral scales (areas I and II of Esin 1990). Presumably these were aligned in staggered pairs along the 'ridge' line. No bilaterally symmetrical scales have been observed. In other Devonian, and more recent, palaeoniscoids there is wide variation in the distribution of paired and unpaired fulcral scales. Of those species found in Australia, the Late Devonian *Howqualepis rostridens* Long 1988 has unpaired dorsal and ventral fulcral scales on the posterior half of the body; *Mimia toombsi* Gardiner and Bartram 1977 has unpaired fulcra along the whole body dorsally, and ventrally from the pelvic fin to the tail; *Moythomasia duagaringa* Gardiner and Bartram 1977 has unpaired fulcra in front of all unpaired fins except the anal fin (Gardiner 1984). According to Kazantseva (1976) fulcra were initially paired in palaeoniscoids; i.e., in the primitive condition there were no symmetrical fulcra. As *Ligulalepis* is one of the oldest palaeoniscoids found in the fossil record (Late Silurian of China – Wang & Dong 1989), it would be expected to lack symmetrical (i.e. unpaired) fulcral/keel scales.

Although lepidotrichia are rare, they appear to be of a distinctive form. Like the body scales, their structure indicates they were more tightly locked together than those of other fishes.

Functional interpretations

Scales with high depth:length ratios, from the mid-flank region, are quite strongly curved (Fig. 2c). Perhaps this is of significance in relation to the extra interlocking device – i.e., the rostro-dorsal process. The 'abnormal' palaeoniscoid *Cheirolepis* (see Pearson & Westoll 1979, Pearson 1982) has micromeric squamation and also lacks the typical interlocking devices (pegs and sockets) of its contemporaries, the stegotrachelid palaeoniscoids. *Ligulalepis* scales of the same form as the holotype have the highest depth to length ratio reported for any Palaeozoic

palaeoniscoids, and their strong curvature implies a low scale number per scale row, perhaps 10 or fewer. Scales of platysomoids have a high depth:length ratio, but other features of *L. toombsi* scales would preclude them from belonging to a platysomoid (e.g. their strong curvature, and their rostro-dorsal processes). A box-shaped or circular transverse section would be ruled out by the fact that mid-flank scales show the greatest curvature. A fusiform shape is indicated by elimination of these other possible shapes, and by the correlation shown in this paper between the scale types observed for *L. toombsi* with those observed for more recent fusiform fishes.

There is apparently a correlation between the size of scales and the degree of their interlinking. For example, the Cretaceous palaeoniscid *Cteniolepidotrichia* probably comprises two species (Poplin & Su 1992), one having deep scales equipped with pegs and sockets, and the other having smaller squarish scales without pegs or sockets. The body covering of large scales indicates that *Ligulalepis* did not swim in the shark-like fashion envisaged for *Cheirolepis* by Pearson and Westoll (1979). Peg and socket articulations would have constrained dorso-ventral flexibility, while the anterior processes limited the lateral flexibility of the body. The large interlocked scales probably indicate that swimming involved low amplitude undulations. The scale rows would have acted to brace the sides of the trunk, preventing twisting of the body. Contemporaneous fish with non-micromeric squamation included many placoderms, whose early forms had armour extending onto the trunk so that the front half of the body was stiffened. Gottfried (1991) suggested that this stiffening, for placoderms and deep-scaled fish, also assisted air ventilation by recoil aspiration, as among polypterids. In any case, *Ligulalepis toombsi* appears to have had the least flexible trunk region of any known palaeoniscoids.

It is not possible to infer the likely habitat of *L. toombsi* by analysis of the other microvertebrate remains in the same samples. At some sites, acanthodian and placoderm scales were most abundant, while at other sites thelodont scales predominate. This diversity of faunal associations may indicate that *L. toombsi* had an extensive ecological range, from near shore environments to further out on the continental shelf.

Acknowledgments

I wish to thank Dr John Pickett and the Geological Survey of NSW for providing the samples used in this study. Dr Sue Turner assisted with techniques for sorting the samples and gave helpful advice; Mr Rick Webb helped with SEM photography, Dr Gavin Young (AGSO) provided information, and Dr. Tony Thulborn gave helpful advice and criticism.

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CAPE HILLSBOROUGH: AN EOCENE – OLIGOCENE VERTEBRATE FOSSIL SITE FROM NORTHEASTERN QUEENSLAND

GREG MCNAMARA

MCNAMARA, G. 1994. Cape Hillsborough: an Eocene – Oligocene vertebrate fossil site from northeastern Queensland. *Rec. S. Aust. Mus.* **27**(2): 187–196.

The Hillsborough Basin is a narrow graben that parallels the modern coast between Prosperine and Mackay, north Queensland. At Cape Hillsborough, just north of Mackay, Hillsborough Basin deposits outcrop. Here a succession of volcanic and volcaniclastic rocks, oil shales and ostracodite named the Cape Hillsborough Beds are well exposed. The Cape Hillsborough Beds are informally subdivided into a dominantly volcanic succession, termed the Cape Hillsborough volcanics, separated by an angular unconformity from an underlying ostracodite and oil shale succession termed the Wedge Island beds.

The Wedge Island beds contain vertebrate fossils including ubiquitous teleost bones, turtle (chelid) bones and crocodile scutes.

Palynoflora extracted from Wedge Island beds oil shale indicates a Middle Eocene age based on correlation with the *Nothofagidites asperus* Zone. A mean K/Ar age of 32.5 ± 0.4 Ma on the Cape Hillsborough volcanics provides a minimum Early Oligocene age for the underlying sediments and the Cape Hillsborough fossil fauna. The fauna is therefore derived from one of the better dated Early Tertiary vertebrate fossil sites in Australia.

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Cape Hillsborough is a coastal promontory on the northeastern Queensland coast located between Mackay and Proserpine (Fig. 1). Hillsborough Basin sediments and volcanics are well exposed here. The Hillsborough Basin is a narrow graben structure within Palaeozoic volcanic, plutonic and sedimentary rocks. It trends south-southeast from Proserpine under Repulse Bay and the Hillsborough Channel to near Mackay.

The Cape Hillsborough area was probably a horst relative to other parts of the Hillsborough Basin graben which resulted in a thinner stratigraphic pile developing and a sequence of sediments and volcanics which are not readily correlated with sequences elsewhere in the basin (Slessar 1970).

Geology

The Cape Hillsborough Beds

At Cape Hillsborough, outcrop is dominated by about 300m of felsic and mafic pyroclastics and lava flows overlying oil shale and limestones collectively termed the Cape Hillsborough Beds. The type locality for the Cape Hillsborough Beds (Clarke *et al.* 1968) takes in all the north – northeastern cliff exposures from Cape Hillsborough to Andrews Point within the Cape Hillsborough National Park (Fig. 2).

The Cape Hillsborough area encompasses all known exposures of Cape Hillsborough Beds (Slessar 1970). They consist mostly of rhyolitic and basaltic lavas and pyroclastics but comprise a complex interfingering of volcanic and volcaniclastic rocks deposited during a short lived episode of pyroclastic volcanism. Small exposures of underlying sediments occur at low tide revealing approximately 15 m of succession. Slessar (1970) interpreted these sediments as the upper part of a more extensive oil shale sequence with which the volcanics are unconformable.

Remapping has confirmed the volcanics and sediments are not conformable but are divided into two units by an angular unconformity. The sediments below the unconformity are informally termed the Wedge Island beds after the key outcrop at Wedge Island. They encompass other sequences recorded from Donna Bay, Mackay Oil Prospecting Syndicate (MOPS) 4 and MOPS 5 drill holes, GSQ Proserpine 1–2RA drill hole and other outcrops mapped by Slessar (1970) but not relocated by the author (Fig. 2). The overlying volcanics are informally termed the Cape

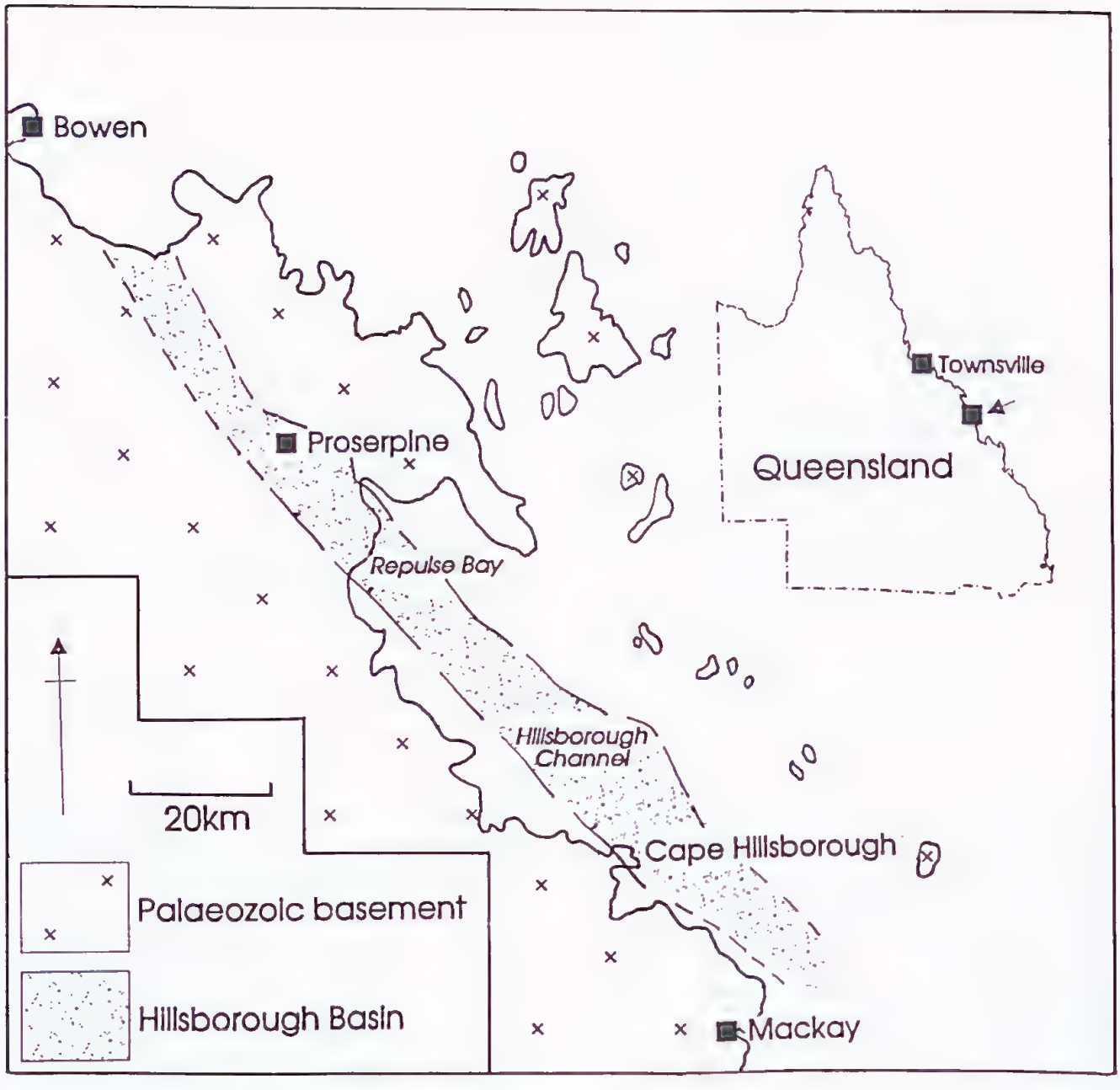

FIGURE 1. Regional geology and location of Cape Hillsborough.

Hillsborough volcanics and include all Tertiary volcanics, volcaniclastics and epiclastics outcropping stratigraphically above the Wedge Island beds in the Cape Hillsborough area (mostly within Cape Hillsborough National Park; Fig. 2).

Slessar (1970) noted the sediments contained fossil plant material, invertebrates and fish bone. Other vertebrate fossils from the Wedge Island beds are described here. Tuffaceous sediments within the Cape Hillsborough volcanics have yielded angiosperm leaves and other plant material (Clarke *et al.* 1968). The existence of fossiliferous tuffs and volcaniclastics in the sequence raises the interesting possibility that vertebrate fossils may also be present within the volcanic pile. The author located a boulder-sized piece of silicified wood [JCU F12517] in a pyroclastic breccia halfway between Cape Hillsborough and the GSQ Proserpine 1–2RA drill hole (Fig. 2). This indicates significant quiescent periods occurred between eruptive events that would have allowed for the return of vertebrates to the area over the life of the volcanic activity.

Stratigraphic relationships and age of the Wedge Island beds

Slessar (1970) correlated the outcropping Wedge Island beds with the oil shales and

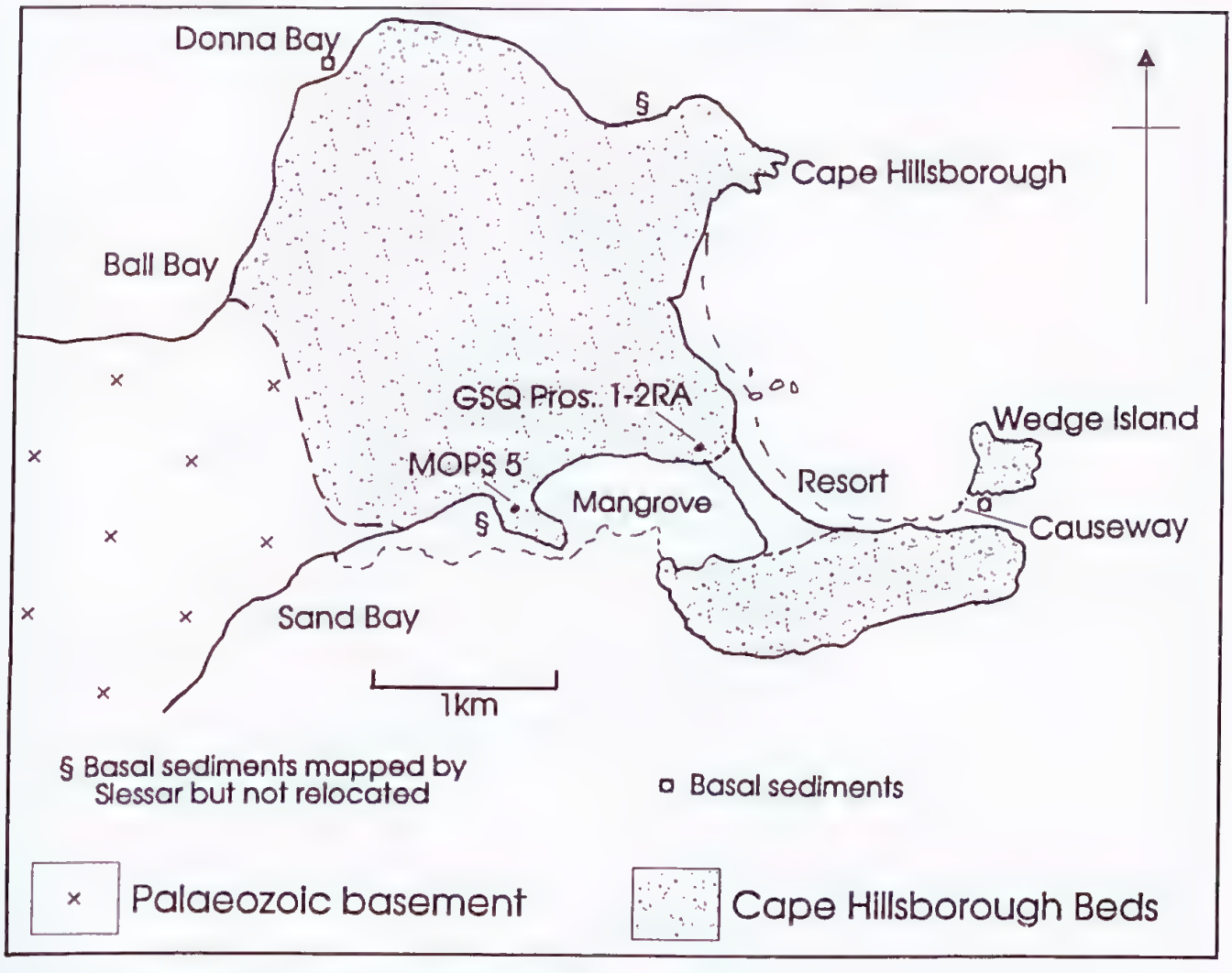

FIGURE 2. Geology of Cape Hillsborough National Park (after Slessar 1970).

sandstones intersected in the wells MOPS 4 and MOPS 5 drilled in 1956. The wells were drilled in the southern part of the Cape Hillsborough study area. The stratigraphic relationship between the sediments and volcanics is not delineated by these drill holes because they only intersected the sediments (Clarke *et al.* 1968). However, there is no doubt Slessar's correlation is correct. The location of MOPS 4 and MOPS 5 is less than 50 m from an (unrelocated) outcrop of the sediments (Fig. 2). Bedding attitudes at this locality and Donna Bay indicate that the sequence dips under the volcanics. There is no evidence of a faulted contact. Intersections recorded for MOPS 4 & MOPS 5 do not include bimodal volcanic units between the sedimentary sequence and the Palaeozoic basement, further confirming the view that the sediments are basal to the volcanics rather than the volcanics being faulted in from below the sediments.

In 1971 a stratigraphic bore (GSQ Proserpine 1–2RA) was put down by the Queensland Mines Department at Cape Hillsborough (Fig. 2). The Wedge Island beds were intersected approximately 30 m below the volcanics, continuing to a depth of 453 m, thus confirming the interpretation of Slessar. The sediments in this section were logged as interbedded mudstone, shale, siltstone, sandstone and oil shale (Swarbrick 1974).

There is only one outcrop, located at the northern end of the Causeway (Fig. 2), where the contact between the sediments and volcanics is exposed. Slessar (1970) interpreted the contact at the Causeway as an angular unconformity but remapping of the site in 1987 showed it to be a fault. Dip measurements indicate that the Wedge Island beds are folded with the north-dipping limb of a gently plunging anticline truncated against subhorizontal basalt. The exposed fault is steeply dipping and trends almost parallel with the strike of the north-dipping beds (Fig. 3).

Both rock types are brecciated at the contact but no sense of movement is apparent. Assuming the folded sediments are expressing a tectonic event

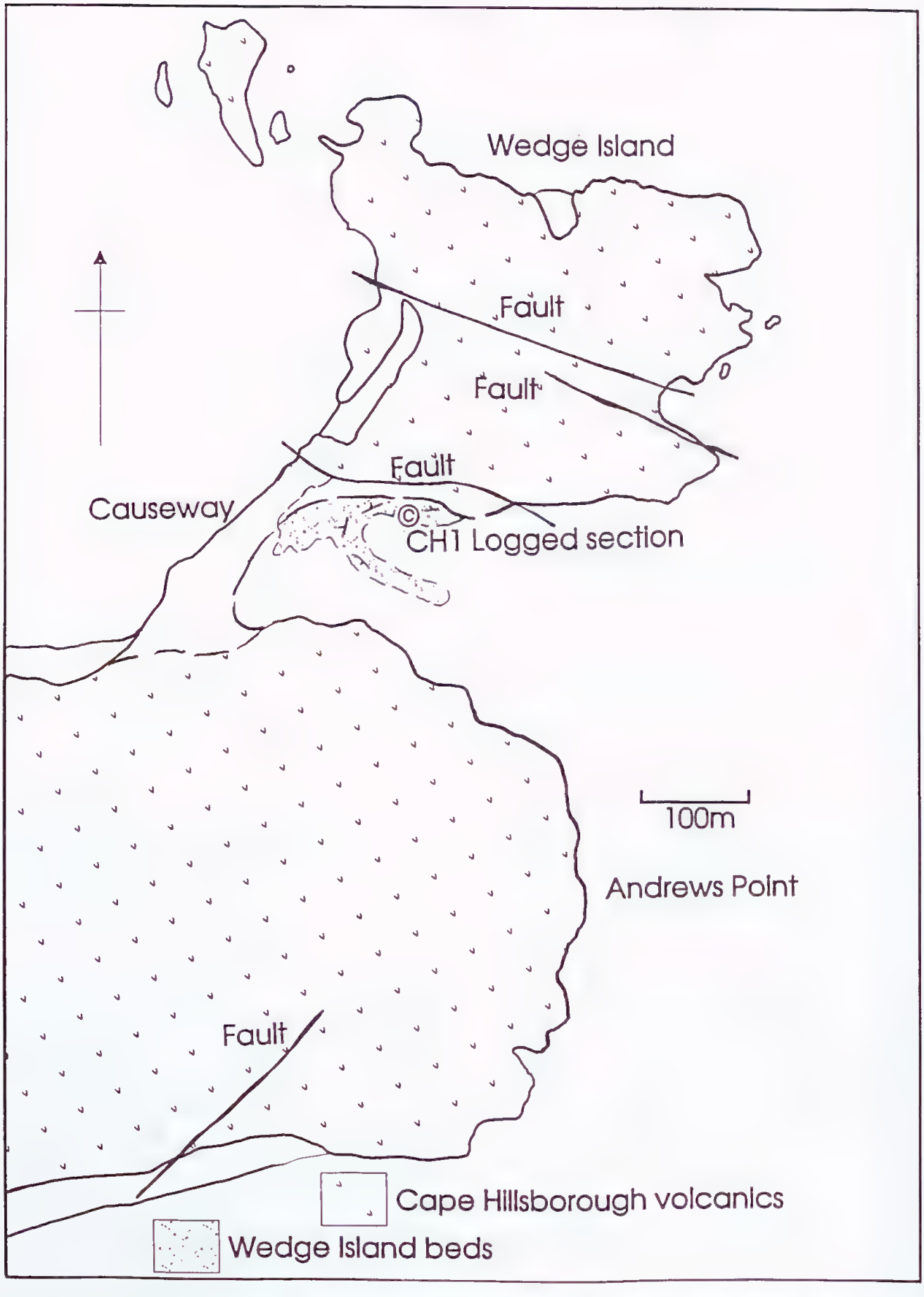

FIGURE 3. The geology of Cape Hillsborough between Andrews Point and Wedge Island and the location of the main fossil deposit at the Causeway.

that pre-dates the volcanism, it follows that the fault block containing them has been uplifted relative to the volcanics. The causeway outcrop sits at a marginally higher elevation than other outcrops of sub-volcanic sediments. It seems unlikely that all other sub-volcanic outcrops would be faulted-in to near the same level. A more likely explanation is that the other outcrops express undisturbed relationships and the causeway sequence, although repositioned by faulting, has not experienced large vertical displacement.

Slessar did not find contacts for any of the other outcrops of Wedge Island beds (Fig. 2) but assumed they were contiguous on the basis of coincident dips and the interpreted angular unconformity at Wedge Island. However, the stratigraphic relationship between the Wedge Island beds and the Cape Hillsborough volcanics is not in question, only the size of the hiatus between them. The timing of tectonism with respect to the volcanism and the stratigraphy revealed in GSQ Proserpine 1-2RA clearly indicate that the Wedge Island beds, and hence the vertebrate fossils they contain, are sub-volcanic. The folding of the Wedge Island beds at the Causeway indicates an angular unconformity *does* exist between the sediments and the Cape Hillsborough volcanics even though the faulted contact does not.

Hodgson (1968) analysed samples from MOPS 4 and MOPS 5 for spores and pollen. MOPS 4 produced a good yield of well preserved pollen whereas MOPS 5 failed to produce a microflora. The palynoflora from MOPS 4 included *Haloragacidites harrisii, Nothofagus* cf N. *deminuta* and *Inaperturopollenites* sp. and thus Hodgson (1968) concluded that the sample was probably Lower Tertiary in age. Hekel analysed samples collected by V. Palmieri at Donna Bay and material from MOPS 5. For Donna Bay samples, he recorded elements of the *Cupanieidites orthoteichus* zonule, including its nominate species, indicating a Paleocene to Early Eocene age and probably constrains the maximum age as Late Paleocene (Hekel 1972; Foster 1980). Slessar (1970) listed a flora provided by Hekel for MOPS 5 and noted it contains elements of the *Cupanieidites orthoteichus* zonule together with elements of the *Myrtaceidites eugeniiodes* and *Gambieriana edwardsii* zonules then believed to be of Paleocene age in South Australia (Harris 1971). Hekel (1972) concluded that the Cape Hillsborough Beds must be Paleocene to Middle Oligocene in age by correlating them with the Hillsborough Basin sediments known at Proserpine from extensive drilling (eg AEQ Proserpine 1 (Hutton 1980)).

Samples were collected at the Causeway by the author [JCU 36309 – 36320] in an attempt to improve palynological data. The resultant palynofloras were assessed by consultant palynologists McEwan-Mason and Wagstaff, Melbourne and also Neville Alley, South Australian Department of Mines and Energy. The yield of palynomorphs was poor but their preservation was fair to good (N. Alley pers. comm.). The initial assessment (McNamara 1993) indicated a palynoflora that provided no useful biostratigraphic information (N. Alley pers. comm.). Subsequent assessment provided a more useful palynoflora.

The dominant taxa in these samples are *Haloragacidites harrisii* and *Araucariacites australis. Malvacipollis diversus, Nothofagidites deminutus, N. heterus, Rhoipites* spp., *Podocarpidites* spp. and *Triorites* cf. *T. orbiculatus* (Foster 1982) are all present in significant numbers.

It is noted that *Proteacidites* frequency and species diversity is relatively low, with the most consistent of the seven species present being *Proteacidites pachypolus. Proteacidites kopiensis, P. reticulatus, Triporopollenites gemmatus, Anacolosidites sectus* and *Nothofagidites falcatus* are present. Rare occurrences of *Diporites aspis, Crassoretitriletes vanraadshooveni, Malvacearumpollis mannanensis, Polyodiaceoisporites retirugatus* and *Polypodiidites usmensis* are also noted.

The palynofloras lack the characteristics of Australian Paleocene and Early Eocene assemblages, missing the typical common to locally abundant taxa. The palynofloras are also not typical of Late Eocene and Oligocene assemblages (N. Alley pers. comm.). Significantly, they lack *Triorites magnificus* which is a reliable indicator of early Late Eocene time, its first appearance defining the base of the Middle *Nothofagidites asperus* Zone of the Gippsland Basin (Stover & Partridge 1973) which coincides with the base of Late Eocene.

The first appearance of *Nothofagidites falcatus*, present in the samples, defines the base of the Lower *Nothofagidites asperus* Zone (Stover & Partridge 1973) which corresponds with the early Middle Eocene. This indicates a Middle Eocene age for the Wedge Island beds. A correlation with the *N. asperus* Zone is supported by the lack of *Triorites magnificus* and the presence of *Anacolosidites sectus* which is restricted to the

Lower *N. asperus* Zone. Further support is given by the presence of *Proteacidites kopiensis* and *P. pachypolus* whose range ends in the Lower *N. asperus* Zone (Dudgeon, 1983).

Dudgeon (1983) correlated the central Queensland Yaamba Basin deposits with the *Nothofagidites asperus* Zone using a very similar palynoflora. It too was derived from an oil shale succession. This suggests the Rundle, Yaamba and Condor oil shale successions are penecontemporaneous and all Eocene in age. However, diachronous species ranges between Queensland basins and the Gippsland Basin, 15° to the south, must be considered. Foster (1982) and Dudgeon (1983) concluded that apparent upward range extensions of species in Queensland did not invalidate the use of southern Australian data. This does not diminish the problem of diachronous ranges produced by latitudinal effects on the temporal distribution of flora. Latitudinally controlled zones occur earlier in northern sequences rather than later (N. Alley pers. comm.).

Sluiter (1991) noted that floral differences between Eocene Lake Eyre sediments and southern sites are not great, even though Lake Eyre is 9° further north (about half way between the southern sites and Cape Hillsborough). Sluiter (1991) suggested this lack of difference may be due to a weak equator to pole gradient for this period (Kemp 1978). If Sluiter is correct it may mean there is little latitudinal bias in Eocene species distribution and the Middle Eocene age correlation for the Wedge Island beds is reasonable.

McDougall and Slessar (1972) dated six samples (with concordant results) from the Cape Hillsborough volcanics, with a mean age of 32.5 ± 0.4 m.y. (Early Oligocene). This age is consistent with the stratigraphic relationship between the Cape Hillsborough volcanics and the Wedge Island beds and the angular unconformity between them.

The age of the volcanics is commonly quoted as the age of the whole of the Cape Hillsborough Beds which is misleading. A considerable hiatus, perhaps as much as 12Ma, separates the Wedge Island beds and the Cape Hillsborough volcanics.

The new floral data from Wedge Island concurs with previous palynological assessments of an Early Tertiary age. It refines the age of the beds and is significant for two reasons. Firstly, it indicates the deposit is much older than the Oligocene age of the overlying Cape Hillsborough volcanics. Secondly, it clearly demonstrates a Middle Eocene age for the vertebrate fossils.

Stratigraphy and sedimentology of the Wedge Island beds

At the Causeway outcrops of Wedge Island beds delineate a small anticline gently plunging towards the northwest. The beds inclined at 20° on the northern limb are exposed at low tide and represent 15m maximum vertical thickness (Figure 3). At Donna Bay the thickness accessible above the low water mark is approximately 2m and the facies associations are distinctly different. Both sequences have abundant bone preserved within the coarser facies.

Four facies are recognised:

Facies 1: Ostracodite. A lime-rich, cream-coloured, sometimes cross-bedded sandstone with occasional pebble sized, well rounded, allochthonous clasts and rip-up clasts. Sand grains are principally ostracod skeletons but terrigenous grains of quartz, feldspar and lithics are present. It is generally carbonate cemented and fossil bones (light brown) are present throughout [JCU 36315, 36316, 36318, 36320 & 36321].

Facies 2: Muddy limestone. Cream-coloured, massive siltstone/mudstone. Induration varies from fully lithified to virtually unlithified dependent on the degree of carbonate cementation [JCU 36314, 36317 & 36319].

Facies 3: Grey-brown shale (oil shale). Finely laminated. Oily efflorescence sometimes apparent. Carbonaceous plant impressions present throughout. Poorly indurated, sea washed sections appear massive [JCU 36309, 36310, 36311, 36312 & 36313].

Facies 4: Brown pebbly sandstone. Variable grainsize (very fine-very coarse) both laterally and vertically. Grains dominantly terrigenous but ostracods very abundant. Iron oxide staining common. Fossil bone (jet black) present throughout. Carbonate cement [JCU 36322].

The Causeway facies association

Two distinct facies groupings are present in the Causeway section. The base of the logged section is a monotonous sequence of Facies 3. It is at least 7.5 m thick, extends out beyond the low tide mark, and crops out very poorly (Fig. 4). It contains traces of plant material and has yielded pollen and fungal spores but no bone was found.

The oil shale is replaced up section by a

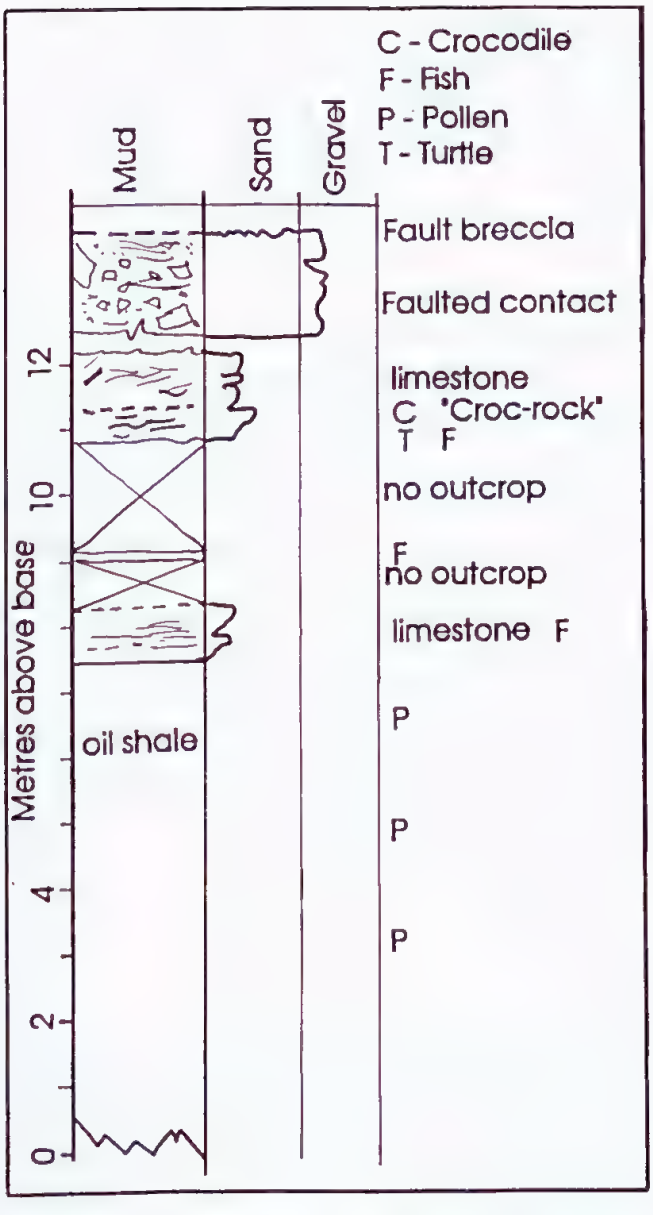

FIGURE 4. Logged section CH1: Wedge Island beds, Wedge Island.

sequence of interbedded muddy limestone and ostracodite but the contact is obscured (Fig. 4). Many of the ostracodite outcrops have sharp bases and appear to grade into the muddy limestone facies. They may represent a fining upwards association but in other outcrops the distinction between the two facies is more pronounced and no fining upwards association is apparent. The maximum thickness expressed by this association is 4.5 m (Fig. 4) but is variable along strike.

The Donna Bay facies association

The thickness available for logging at Donna Bay during low tide amounts to approximately 2m. More is exposed above the intertidal zone but it is mostly covered by a beach boulder bed. Consequently it was decided there was little value in logging the section. The facies association at this locality does not include either of the Causeway limestone lithologies but the rocks are carbonate rich. Instead there is an interbedded sequence of grey-brown shale and brown pebbly sandstone. The beds of both types grade between each other over a short distance but sharp contacts are uncommon. Carbonate is present as abundant ostracod valves and as cement.

Fossil bone is found in both facies at this locality but principally in the brown pebbly sandstone.

Wedge Island beds environment of deposition

Oil shales develop in anoxic environments such as deep freshwater and hypersaline lakes (Demaison & Moore 1980). Green & Bateman (1981) concluded that the Hillsborough Basin is structurally similar to the East African rift system and that the large anoxic lakes found in that system are a good modern analogue for the depositional environment of the Hillsborough Basin although marine incursions must have also occurred. Green & Bateman (1981) propose a hypothetical 'Condor Lake', at a palaeolatitude of approximately 45° south, developed in an intramontane graben. Sedimentation kept pace with prolonged subsidence, allowing for the accumulation of very thick fluvio-lacustrine sequences of oil shales and other sediments. Dinoflagellates, acritarchs and alginite B in some sections together with anhydrite and gypsum crystals indicate brackish to marine conditions suggesting the basin was sometimes open to the sea (Green & Bateman 1981) whereas the alga *Pediastrum* sp. in other sections indicates a freshwater environment (Foster 1980).

The near-shore environment was dominated by a temperate rainforest flora, similar to forests containing *Nothofagus fusca* type trees found in Tasmania and New Zealand today. Temperatures were probably mild; averaging 17–18°C (Sluiter 1991). The forest was probably relatively closed and probably grew very close to the depositional basin (Martin 1978). This type of temperate forest is ideal habitat for a wide range of birds, mammals and other animals today and there is no reason to think that it would have been any less hospitable during the Eocene.

Slessar (1970) identified ostracods from Donna Bay as Limnocypridae, *Bisulcocypris* and *Metacypris* and noted that they indicate a non-marine environment but provided no stratigraphic

insights. Ostracods collected by the author from Wedge Island were too damaged and too well cemented to identify (P. De Deckker pers. comm.). Freshwater ostracods identified from the Rundle and Duaringa oil shale sequences, which are similar to the Wedge Island sequence, suggest deposition in a shallow (approximately 1 m deep) oxygenated lake (Fleming *et al.* 1979).

The ostracodite is not a conventional limestone. It is a fluvio-lacustrine deposit where the dominant grain type is paired ostracod valves [JCU 36321]. Other, non-biogenic, non-carbonate terrestrial grains are common. The bulk of the carbonate in the rock is cement infilling the ostracod valves and occluding pore-space. The valves themselves may have provided some soluble carbonate for precipitation through abrasion and dissolution prior to deposition but they are only calcified chiton, not carbonate. Pebble sized terrigenous clasts and muddy/silty limestone rip-up clasts are well rounded. Cross-bedding is evident in many of the boulders strewn on the causeway but not so obvious in outcrop. Fish bones are entirely disarticulated while the turtle bones are carapace fragments and carapace-plastron sections which do not readily disintegrate, even in energetic streams.

The ostracodite therefore, most likely represents the reworking of fluvial terrigenous input and lacustrine accumulations of ostracod, fish, turtle, crocodile and ?other vertebrate debris. Assuming a freshwater to brackish water environment prevailed, a wave-washed lake margin with numerous small streams debouching into a ?very shallow to shallow lake seems an appropriate environment to generate such a sediment. The ostracodite-muddy limestone facies transitions may even be recording transgressive-regressive lake levels with the anoxic oil shale facies representing the deeper, off shore, sections of the lake. Rip-up clasts may indicate occasional sub-aerial exposure of the marginal lake floor or proximity to a stream flowing into the lake.

The ostracodite-limestone facies is not recorded elsewhere in the Hillsborough Basin (Green & Bateman 1981; Green *et al* 1984) but is recorded in the oil shale sequences of the Rundle Formation further to the south (Coshell 1983). The Rundle Formation contains sequences of oil shale and ostracodite that are virtually identical to the Wedge Island sequence. Coshell (1983) proposed a shallow lacustrine environment for the deposition of the Rundle Formation sediments and noted that depositional cycles included transgressive and regressive events causing reworking of lake sediments by wave action and brecciation through sub-aerial exposure. Ostracodite horizons were recognised by Coshell (1983) as representing very shallow lacustrine conditions that only rarely were associated with sub-aerial exposure.

Palaeontology

The Wedge Island local fauna

Vertebrate fossils at Wedge Island are confined to the ostracodite and muddy limestone facies. Bone material is commonly an unidentifiable hash but there are abundant spines and vertebrae which clearly indicate that the bulk of this material is from fish.

The Wedge Island local fauna is described below. Unfortunately none of fossils are sufficiently diagnostic to allow the taxon it represents to be identified in detail. The specimens have not been figured for this reason. The concept of the local fauna follows Tedford (1970). Catalogue numbers refer to specimens catalogued and held at James Cook University.

Crustacea

Ostracoda

Ostracod shells form a significant clastic component in the ostracodite facies but can also be found in oil shales and siltstones at Donna Bay [JCU 36323, 36324] (Slessar 1970).

Mollusca

Gastropoda

Casts of naticoid gastropods are common in the Ostracodite and muddy limestone facies at Wedge Island and are very common in some horizons at Donna Bay but cannot be more accurately identified [JCU 36325].

Osteichthyes

Teleostei

Fish spines, vertebrae and other 'fish hash' are ubiquitous and can be found in all of the non-oil shale facies. No articulated material or diagnostic bone has been found [JCU 36326, 36327].

Reptilia

Chelidae

Turtle carapace and plastron sections and

fragments are the most common fossils in the deposit after fish. They probably represent chelid bone but the ornamentation and suturing features are not diagnostic and no further refinement in the identification is possible (Gaffney, pers. comm.; Gaffney 1991) [JCU F12509, F12510, & F12511].

Crocodylidae

Several distinctly crocodilian dermal scutes were found at Wedge Island in an outcrop dubbed 'croc-rock' – CH1: 11 m (Fig. 4). While quite characteristic of the family they are of no help in further identification (Molnar, pers. comm.) [JCU F12512 & F12513].

Problematica

Coprolites were also found in outcrop at croc-rock. While these particular specimens have no diagnostic value they are large enough to have come from a crocodile [JCU F12514]. One specimen however, is reminiscent of stools left by large aquatic birds such as swans [JCU F12515].

Provenance and bias of the Wedge Island local fauna

A shallow lacustrine environment would have provided favourable habitats for many vertebrates but may not have been conducive to the preservation of their remains. Oil shales and other anoxic sediments that preserve plant material are not necessarily suitable for preserving bone. There is very little bone present in the oil shale outcrops at Wedge Island. The casts of fish vertebrae reported by Green and Bateman (1981) indicate bone dissolution is taking place locally within the Condor oil shales.

Conversely, the chemical conditions for bone preservation within the limestones were probably quite good, especially if cementation occurred rapidly after deposition. However the ostracodite was in fact a fluvio-lacustrine deposit involving the transport and reworking of sedimentary components including bones. Such an environment was destructive of articulated remains and of individual bones through mechanical abrasion.

Terrestrial animals would have had their remains abraded during fluvial transport to the lake and through wave action on beach and deltaic bedforms (Napawongse 1981). Aquatic animal remains would also have been subject to wave action but not the dual action of fluvial transport and lacustrine reworking. Therefore, despite a favourable habitat, the depositional environment of the ostracodite facies mitigated against the preservation of bone of terrestrial origin.

Additionally, biogenic degradation of bone may be expected even before any bone transport begins. Teeth are likely to survive longer than many bones but anything that remains will be greatly diluted in the sediment load relative to the remains of aquatic taxa.

Not surprisingly then, all the bone found to-date derives from aquatic species with the most abundant fossil taxa (fish) simply reflecting the natural aquatic abundance probably present in the depositional system and the number of individual spines, vertebrae and other bones to be found in the average teleost. Turtle carapace bones and crocodile scutes are dense, robust bones likely to survive mechanical abrasion. In addition, turtles and crocodiles are likely to be common taxa in a lacustrine environment and each individual has a large number of such bones or scutes.

Recommendations for future work at Cape Hillsborough

It is unlikely that since fish, turtle and crocodiles were present, the lacustrine environment and surrounding terrestrial habitat was hostile to other vertebrates. Even though not a single bone or tooth from a non-aquatic taxon was found, the importance of this site remains undiminished.

Given the small number of Palaeogene vertebrate fossil sites and the degree of age control on the Wedge Island beds, one of the best-dated Early Tertiary vertebrate bearing units in Australia, this unit has good potential for important future discoveries. The potential for vertebrate fossil discoveries in the Cape Hillsborough volcanics should also be explored. It is recommended the succession be routinely prospected.

Acknowledgments

The Queensland National Parks Service provided permission for fossil collection and support on site. James Cook Univeristy provided Special Research Grant funding to allow the research to proceed. Professor Bob Henderson, James Cook University, is thanked for his comments on earlier drafts. Neville Alley, S.A. Dept. of Mines and Energy, is especially thanked for his thorough review of this work and his reworking of the palynological data at short notice.

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THE MIOCENE OSCILLATION IN SOUTHERN AUSTRALIA

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MCGOWRAN, B. & LI, Q. 1994. The Miocene oscillation in southern Australia. *Rec. S. Aust. Mus.* **27** (2): 197–212.

Warm times are moister times and times of higher sea level. They are represented by more extensive stratigraphic records, richer fossil assemblages, and more precision and confidence in correlation and age determination. The Miocene marine profile in southern Australia is a profile of episodically advancing seas from the late Oligocene to the early middle Miocene, then a pronounced retreat into the late Miocene. In parallel is the chronological distribution of three warm periods—in the Janjukian stage, the mid-Longfordian stage (early Miocene), and then the twin-peaked Miocene climatic optimum of the Batesfordian-Balcombian stages of the earliest middle Miocene, 16–15 million years ago. After that, there is a pronounced cooling. That rise and fall at 10^7 years scale is the Miocene oscillation. The planktonic foraminiferal record at Lakes Entrance in east Gippsland supports the concept of a rise and fall in sealevel and climate at 10^7 years scale with the superimposition of an oscillation at higher frequency—10^6 years. The match with the global scenario is good. As well, the most pronounced changes in the fossil record are seen within the Miocene climatic optimum, not at the subsequent chilling and fall in sea level. The terrestrial biotas are expected to reveal in due course this three-part Miocene succession: (i) episodically rising trends, Janjukian to late Longfordian; (ii) Miocene climaxes, Batesfordian and Balcombian; (iii) drying and cooling, Bairnsdalian to Mitchellian. The Australian regional stages have a role in the geochronology of Cainozoic biogeohistory; their boundaries should accord with major natural breaks in the stratigraphic record.

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We have undertaken a research program based on the Neogene foraminiferal succession in southern Australia. As the continent 'drifted' north, subsequent to rapid Australia/Antarctica separation commencing in the middle Eocene, it moved into lower latitudes whilst global climate was deteriorating. Its margin was washed by a series of transgressions. In sharp contrast to the trailing passive margin in the south, the northern margin began, during the Oligocene, to accrete terrains—the latest events in a history of tectonic activity stretching back to the Palaeozoic.

There are essentially three reasons for undertaking this research. One is the relevance of a well-developed, mid-latitude, neritic record of calcareous strata to oceanic drilling to the south of Australia in the Ocean Drilling Program—for the neritic-oceanic interaction bears heavily on the problems of reconstructing a global sea level curve and of clarifying links between palaeoceanographic change and palaeoclimatic change. A second stimulus is that the rich neritic record of foraminifera, ostracodes, bryozoa and echinoids, in addition to the molluscs which have long attracted attention, is a splendid resource for studying macroevolution, meaning organic evolution at time scales of 10^6 and 10^7 years. Yet a third reason is that the terrestrial biotas of ancient Australia have left records susceptible to prolonged argument on the two basic and critical questions: What is the 'age' of the assemblage? What was the 'environment' of its community? By supplying the links between continental landform and biotic evolution on the one hand and global change and its geochronological framework on the other, the marine strata at the continental margins can provide something of a reference for addressing both questions. It is this third reason that preoccupies us here, although it is impossible to isolate it from the others.

Consilience of induction: the prime strategy of stratigraphy

The weakest point in virtually all philosophers' systems is the place of history in their scenarios of science and its doing. Among their biological achievements, three luminaries can count some incisive discussion of the fact that not all science is circumscribed by the laws and immanent properties of the physical sciences: Simpson (1963, 1970), Mayr (1982), Gould (1986, 1989).

We can use an example from correlation at

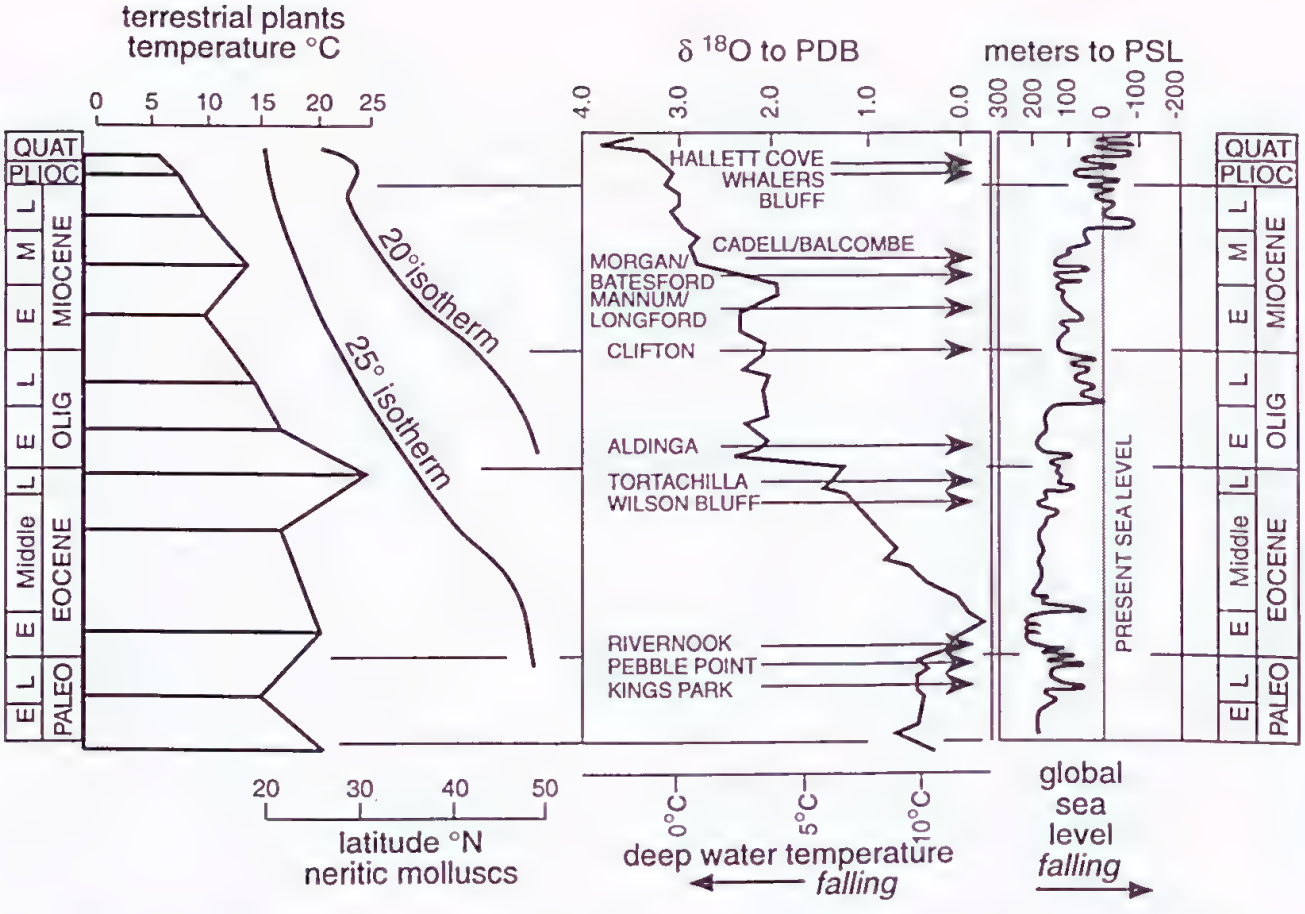

FIGURE 1. Correlation of time series, adapted from McGowran (1991). **Left**, terrestrial plant assemblages from the western U.S.A. yield temperature estimates (Dorf 1955) and molluscan faunas give estimates of latitudinal shift in isotherms (Durham 1950). **Centre**, a composite $\delta^{18}O$ signal from benthic foraminifera in the deep ocean (Shackleton 1985); the thermometer becomes distorted from the Miocene onward by the ice effect. **Right**, the putative curve of global sea level (Haq *et al.* 1987). Note the close general matches among the various kinds of reconstruction: sea level falls as climate deteriorates through the Cainozoic Era. There are mismatches: the molluscan study missed the Miocene reversal; the major fall in Oligocene sea level lagged behind the spectacular fall in isotopic temperature by the duration of the early Oligocene. Also included are the named ingressions and transgressions of southern Australia—benchmarks in the marine record of the southern continental margin.

geological time scale of 10^6 years to make that point. Consider the elegant scenario of Cainozoic change, usually described as global climatic deterioration, in Figure 1 (McGowran 1991). We have long known that the Eocene was a time of global warmth: uniformitarian evidence for that generalization consists of the occurrence of crocodiles, palms, molluscs, corals at higher latitudes than are attained by their modern counterparts (e.g. Lyell 1867). Using the same kind of strategy—extrapolation back from modern biogeographic faunal distribution, including what was known of the environmental requirements of coastal molluscs—Durham (1950) showed that marine isotherms for the western margin of North America have been retreating equatorwards since the Eocene. Similarly, Dorf (1955) could employ terrestrial floras as 'thermometers of the ages' to give a generalized curve for 40–50°N latitude in the western U.S.A. Both strategies are strong, but both are open to quibbling about the reliability of fossil leaves or of shells as indicators of past climatic states. We add Shackleton's (1985) generalized oceanic bottomwater curve of $d^{18}O$ values from benthic foraminifera. That sort of data too could be and was criticized as susceptible to diagenetic alteration, vital effects, salinity changes in the reservoir—criticisms in the same uniformitarian vein as for the fossil curves, and to be taken seriously. And yet the three curves have a powerful mutual similarity! If quite disparate data from the terrestrial, neritic and pelagic realms of the biosphere show such a good mutual match through geological time, then the chances that we are seeing real climatic changes are suddenly much better than they were for each of the data

sets in isolation. The mutual reinforcement of shells, leaves and isotopes is greater than the sum of the parts. Adding a curve of putative global sea level (Haq *et al.* 1987) to the array, we see a strengthening by further persuasive correlations. Sea level has fallen as temperature has fallen, from the same high point in the early Eocene. (There is a nagging mismatch where the major cooling leads the biggest fall in sea level by the duration of the early Oligocene—also heuristic because it demands explanation.)

That lesson in mutual reinforcement by chronological correlation is at Cainozoic time scales. We can amplify the scenario for the Miocene to make the same point by anticipating a major theme of this paper (Fig. 6). McGowran and Li (1993) have correlated two kinds of curve independently to a revised chronology (W. A. Berggren, pers. comm., 1992). One is the oceanic isotopic evidence for the *Mi* glaciations at 10^6 years' scale, rising then falling on the trend at 10^7 years' scale (Wright *et al.* 1992); and the other is the Exxon sea level curve, also at both 10^7 and 10^6 years' scale (Haq *et al.* 1987). The match at both scales is remarkable, even though the independent correlation to the integrated chronology leaves several mismatches at 10^6 years' scale: coolings should fit sequence boundaries, not maximum flooding surfaces, either because of glacioeustatic lowering of sea level, or because lower sea levels enhance continental-type climates. Thus the mismatches can be targeted for scrutiny and a fine-tuning of the correlations.

In both of these examples it is the chronological correlation of disparate data that counts for most. This strategy has a noble ancestry and yet has been curiously unacknowledged (Gould 1986, 1989). Charles Darwin, 'so keenly aware of both the strengths and limits of history, argued that iterated pattern, based on types of evidence so numerous and so diverse that no other coordinating interpretation could stand—even though any item, taken separately, could not provide conclusive proof—must be the criterion for evolutionary inference' (Gould 1986). As Gould notes, the 19thC philosopher of science William Whewell called this strategy of coordinating different lines of evidence to form a historical pattern, 'consilience of induction'. (No matter that Whewell—coiner of 'uniformitarianism' and 'catastrophism'—was an essentialist philosopher (Mayr 1982) with little grasp of Darwin's iconoclastically historical science; or that he not only rejected the thesis of 'On the origin of species...' but banned the book itself (Gould 1989).)

'Consilience of induction' captures the spirit and the strategy of biostratigraphy. How do the strata and their recorded events fit together as a pattern in space and time, and what does that pattern tell us of biogeohistory? This is not an orderly one-way street from correlation to history, but rather a turbulent two-way, hermeneutic thoroughfare. The mutually reinforcing patterns in Figure 1 show the 'Miocene oscillation' or temporary reversal of the grand Cainozoic trend (McGowran, in Frakes *et al.* 1987) clearly, except for Durham's curves. And that is the simplest reason to reject a view of Australian Cainozoic history entrenched in sedimentology, palaeobotany, geomorphology, neritic palaeontology—that we have a somehow special climatic trajectory brought about by Australia's northwards drift to warmer latitudes. Rejected already (McGowran 1979a; in Frakes *et al.* 1987), that view has been supported again by Zinsmeister (1982) and Darragh (1985). The Australian scenario fits the global pattern too well to need *ad hoc* buttressing by auxiliary hypotheses. (Which is not of course to question the importance of Australia's present position to the modern climate.)

The Oligo-Miocene 'sequence'

Consider Figure 2, drawn in 1977. It is a cartoon, a bold conjecture, of course, which attempts to summarize patterns of strata in space and time, to hammer the message that there is a strong parallelism in time through the full range of sedimentary and tectonic environments. As a first-order generalization the pattern still holds, broadly, although it emphasizes the latest Eocene too much and the latest-middle to earliest-late Eocene too little (McGowran 1989a), and the middle Miocene instead of the early Miocene (see below). Those and other corrections are less important than the remarkable gaps in the early middle Eocene, early Oligocene, and late Miocene, giving four Cainozoic 'sequences'. (There is some fossiliferous sediment of early Oligocene and late Miocene age; these are relative statements.) The gaps consist either of hiatuses well constrained by bounding dates, or of markedly regressive facies not well dated, but assuredly occupying only a small part of the time between good dates, or simply an absence or marked rarity of good biostratigraphic records. The theme is repeated and extended but thoroughly substantiated in the palaeogeographic and facies maps of Australia

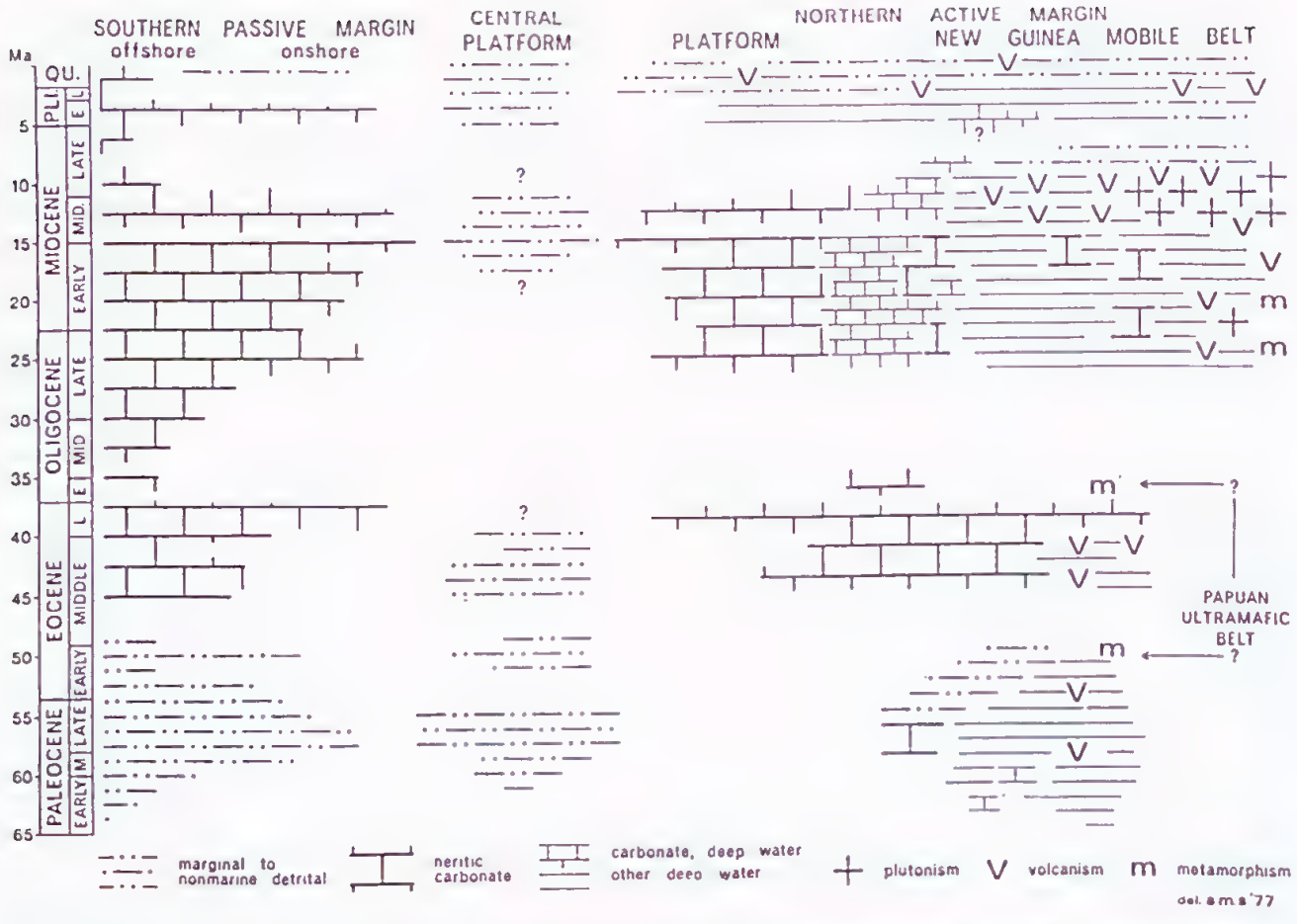

FIGURE 2. Cartoon of sediments versus time across the Australian continent, from McGowran (1979a), intended to show that decades of correlation and age determination—and some interpolation—yielded a pattern of 'sequences' bounded by hiatuses. Obviously, much lithological variety and much continent have been omitted. With some adjustment, the broad contrast between a richer early–middle and a poorer middle–late Miocene stratigraphic and fossil record still holds.

(BMR Palaeogeographic Group 1990). Thus their map 'Cainozoic 2', 52–37 Ma (actually representing most accurately the 4 Ma time slice across the middle/late Eocene boundary, 42–38Ma) displays a generous array of marine facies especially on the southern margin, and nonmarine facies in palaeodrainages and major catchments. It is remarkably similar to 'Cainozoic 4', 30–10 Ma (actually representing most accurately the time across the early/middle Miocene boundary, 20–15Ma), and to 'Cainozoic 6', 5–2 Ma (Pliocene). In stark contrast are 'Cainozoic 3', 37–30 Ma (early Oligocene) and 'Cainozoic 5', 10–5 Ma (late Miocene). At those times all facies, marine and nonmarine, at the margins and across the continent, shrink almost to vanishing point. The cartoon in Figure 2 still holds validly as another way of depicting the Miocene 'sequence'. The sequence is the regional stratigraphic manifestation and signal-bearer of the Miocene oscillation.

Stratigraphic correlation and classification

Australia is antipodeal to the region where Cainozoic stratigraphy developed; it is separated from that region by the tropics; and its terrestrial biotas and much of the neritic biotas carry the stamp of prolonged isolation from the rest of the world. Its northern, heavily vegetated margin in New Guinea excepted, the continent has been stable, lacking the thick, rapidly accumulating sedimentary successions subsequently uplifted and deeply exposed by erosion, as in the Americas and the Himalaya, for example. Instead, we have thinner and more scattered sections with less outcrop and a carapace of deep weathering and duricrusting. Biogeography and the stratal record accordingly give us a double problem: to piece together a highly composite, regional, stratigraphic and biostratigraphic succession; and to correlate that record with the global geochronological standards. As if there were not complaints enough

already, there is a further problem special to the Cainozoic at large, as outlined by Martin Glaessner in a masterful study of half a century ago:

> Biostratigraphic correlation of Mesozoic marine deposits is based on zones which are either worldwide or at least useable within the wide limits of a palaeo-zoogeographic province. Correlation of Tertiary deposits is a much more difficult problem on account of climatic differentiation, topographic isolation, and close stratigraphic subdivision of deposits representing a comparatively short time interval. No worldwide scale of fossil-zones based on well-defined ranges of a set of index-species exists. A sequence of Tertiary faunal assemblages was long ago established in Europe and it is not surprising to find that workers in other continents first turned to this sequence for guidance by means of direct comparison and correlation. As long as no scale of zones is available, the next higher unit in stratigraphic classification, the stage, must be the basic unit for measuring geologic time. The recognition of the European stages in the East Indies proved so difficult that a number of workers gave up and even condemned attempts at inter-continental correlations (Glaessner 1943: 52).

In southern Australia the development of correlation and age determination can be divided into two major periods:

(i) Until the 1940s. The biostratigraphy of the marine record was dominated by molluscs, as it was elsewhere (e.g. Singleton 1941; Darragh 1985). Application of the Lyellian method of percentages of extant taxa had little success, also as elsewhere. Local stages were erected, partly in reaction to the ensuing confusion, partly to facilitate progress within the continent while correlations further afield remained contentious or impossible. But the stages were biological in their essence, based as they were on distinctive macrofaunas based on type localities. 'Correlation was by comparison of gross suites of described molluscs' (Darragh 1985). Until Singleton (1941) redefined the stages on lithological criteria, bringing some order into chaos, the stages were losing their value for two reasons—by becoming 'nothing but convenient labels for certain well-known collecting grounds', and by sometimes being impossibly inclusive, sometimes too restricted to be useful (Glaessner 1951). Re-reading Singleton half a century later, one is struck by how little biostratigraphy he includes—fossils there are aplenty, but they are hardly central to the ordering and arranging of the stratigraphic record. And one is startled to be reminded that Singleton lists not one confident identification of pre-Oligocene strata across the continent, except for the limestones in the northwest where Irene Crespin's studies of larger foraminifera—not molluscs—allowed correlation with the Indo-Pacific letter classification erected in the Netherlands East Indies.

(ii) 1940s to present. Foraminifera were described from the Neogene of southern Australia as long ago as the 1880s (Howchin, 1889) and the same author is acknowledged as one of the very first workers anywhere to describe them from a borehole (Howchin, 1891). Even so, the first substantial shift away from the molluscs and towards the more extensive use of foraminifera and lithostratigraphy in the definition and characterization of stages was delayed for decades, until Crespin (1943). But the most noteworthy event in retrospect was the crisp presentation of three zones and their significance by Glaessner (1951). The *Hantkenina alabamensis*, *Victoriella plecte*, and *Austrotrillina howchini* Zones were non-contiguous—upper Eocene, upper Oligocene, lower Miocene respectively—which upset some purists, but they surely succeeded in fulfilling Glaessner's aim of providing a framework for the future clarifying of the problems seething in the morass of correlation and nomenclature in the southern Australian Tertiaries. As Tertiary correlations and age determinations progressed, most rapidly where microplankton could be used, they did so without the benefit of local stages (e.g. Glaessner and Wade 1958; Wade 1964; Ludbrook 1971), or with the stages merely appended to the biostratigraphy (e.g. Carter, 1964; Ludbrook and Lindsay 1969). Indeed, Singleton (1968) became sufficiently sanguine about progress in clarifying foraminiferal and macrofaunal biostratigraphy to abandon the local stages altogether. McGowran, Lindsay and Harris (1971), attempting the first comprehensive correlation of the local stages to a modern 'global' geochronology, were not at all sure that we were as advanced as all that, and felt that we still needed a local chronostratigraphic focus for the diverse biostratigraphic evidence coming from continental to open marine environments. Even so, one of the authors (Lindsay 1981, 1985) subsequently used the stages extensively whereas another (McGowran 1978-1988) did not. By and large, local stages have not prospered as essential chronostratigraphic tools in this region. In the most comprehensive modern surveys of the classical Tertiary marine fossils, the molluscs, the local stages are used but they do not loom very large (Ludbrook 1973, Darragh 1985).

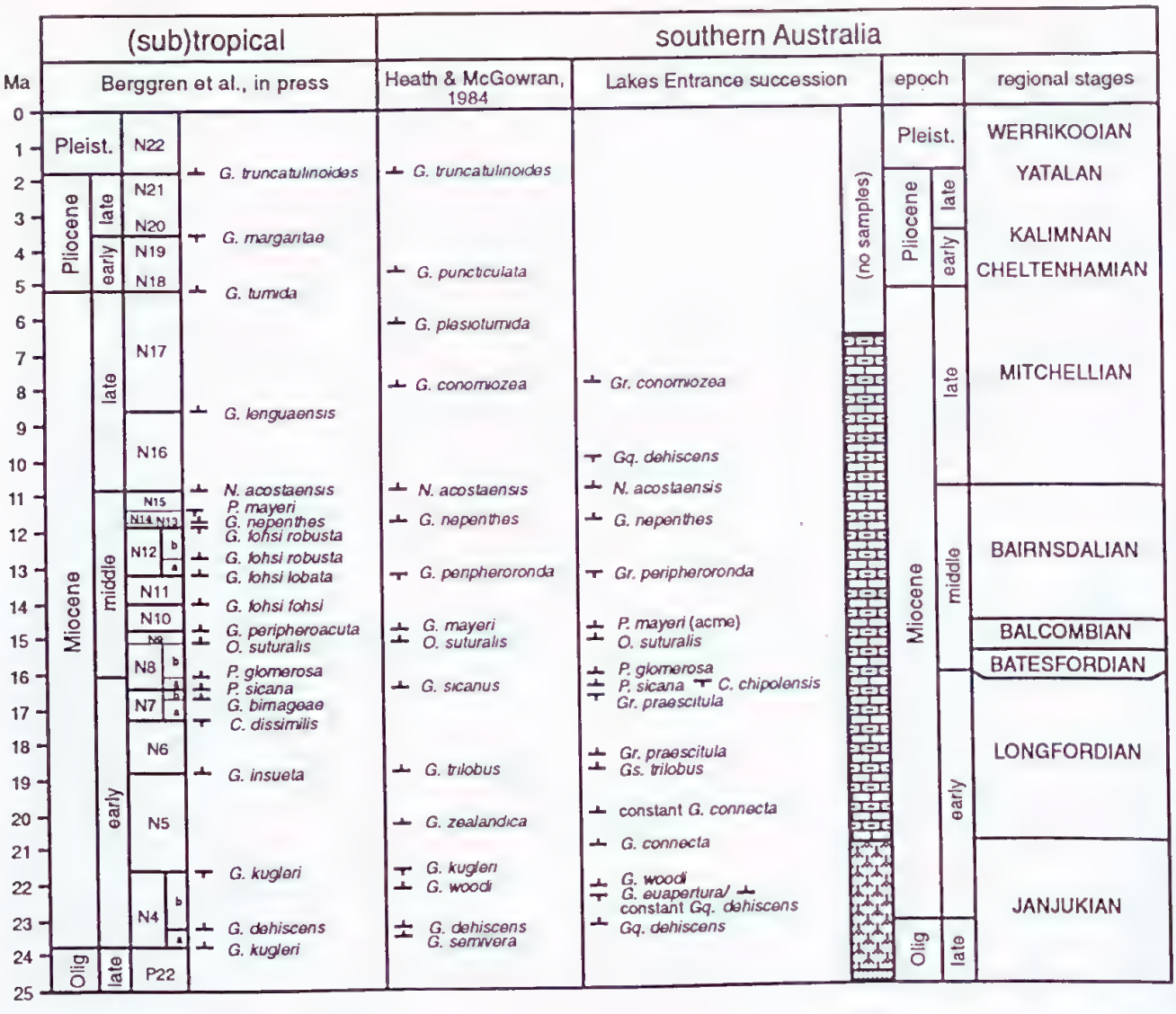

FIGURE 3. The southern Australian planktonic foraminiferal-biostratigraphic succession, shown as first and last appearances (McGowran & Li 1993), is correlated with the standard N-zones of the Neogene (W. A. Berggren, pers. comm. 1992). The regional stages are added at right.

Figure 3 displays a correlation of the local stages with a succession of biostratigraphic events taken from the planktonic foraminifera, which in turn are the main basis for correlation with a standard. Note that local planktonic foraminiferal zones have been abandoned because no consensus was achieved in this terrain of scattered localities and highly composite succession within a greater Tasman region, necessitating continual definition and redefinition of the zones (McGowran, 1978, 1986b; Lindsay, 1981, 1985). Instead, we have sought to compile and improve a detailed sequential ordering of reliable first and last appearances—bioevents or datums, as in Figure 3. At present we are in the uneasy situation of lacking a firm commitment either to routinely used (chronostratigraphic) stages or to stable (biostratigraphic) zones, unlike New Zealand which has both, with the stages well entrenched (Hornibrook *et al.* 1989). Meanwhile, one of us has developed the habit of thinking of the stratigraphic record in terms of marine transgressions (McGowran 1988), and this might be a basis for a renewed consideration of our local stages, as we discuss below. The more prominent transgressions are listed in Figure 1.

Warm peaks and the Miocene optimum

It is necessary to develop all possible precision in generalizing about the trajectory of 'climate' through the Miocene oscillation. The marine neritic record at mid-latitudes ought to reflect fluctuations by the comings and goings of pantropical elements, particularly the larger,

phytosymbiont-bearing, benthic foraminifera. And so it has proved. A summary by McGowran (1979, 1986a) concluded that their highly episodic or sporadic distribution in southern Australia was not merely reflecting a sporadic stratigraphic record, a sporadic distribution of suitable facies, or the vagaries of tectonic docking—the Noah's Ark effect. At any rate there were two well-marked intervals of warming with another not so clear and a fourth predicted to fall in the mid-Longfordian but missing, and now to be documented:

(i) The *Operculina-Amphistegina* interval, upper Janjukian–lower Longfordian, latest Oligocene–earliest Miocene, equivalent to zones upper P22–N4. Actually these taxa are mostly successional with the interface at the first appearance of the planktonic *Globoquadrina dehiscens* and at the Janjukian/Longfordian boundary, as Lindsay (1981) pointed out in discussing the lower *Amphistegina* acme, but they do overlap, and the 'interval' includes a window in which the *Globorotalia kugleri* group penetrates to the mid-latitudes. This warm pulse was not seen in the first of the modern Cainozoic oceanic oxygen isotopic profiles (Shackleton and Kennett 1975), which was correlated a little optimistically to the neritic record (McGowran 1979a).

(ii) The addition to the synthesis: Early Miocene,

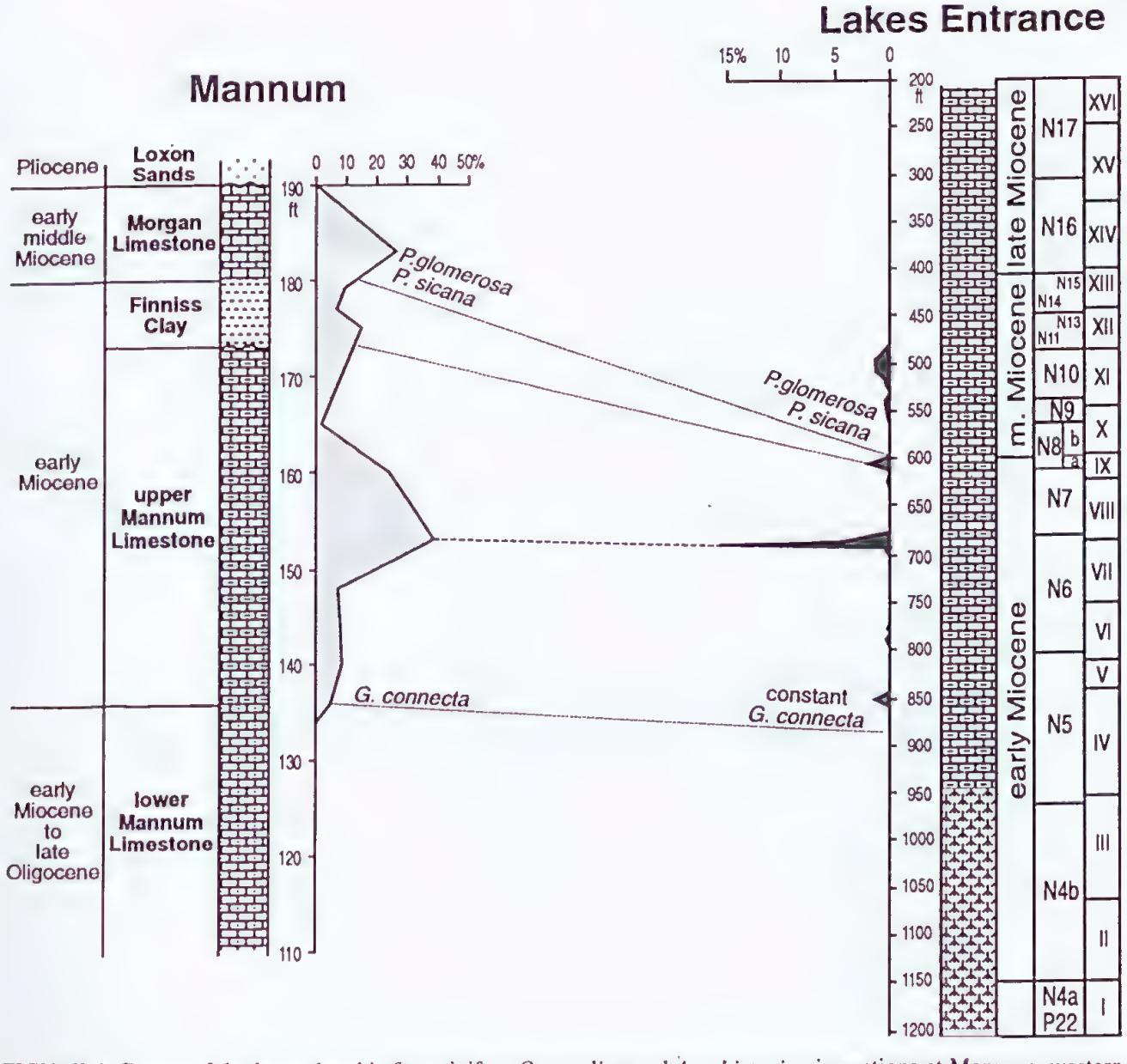

FIGURE 4. Counts of the larger benthic foraminifera *Operculina* and *Amphistegina* in sections at Mannum, western Murray Basin, and Lakes Entrance, Gippsland Basin. Note different scales. Planktonic foraminiferal assemblages I–XVI, from McGowran and Li (1993). This larger foraminiferal horizon in the upper Mannum is between the older Janjukian horizon (but not found in these sections in the lower Mannum), and the younger Batesfordian horizon (the Batesfordian is represented here by the Morgan Limestone, but the larger foraminiferal signature of the climatic optimum has been eroded here).

mid-Longfordian, upper zone N5–N6 equivalent. A well marked peak in the oceanic $d^{18}O$ curve was not matched by a larger foraminiferal spike in southern Australia (McGowran 1979a), even though the oceanic peak was correlated satisfyingly with the *Miogypsina–Heterostegina* horizon and the horizon of giant molluscs in the late Eggenburgian of central Paratethys (McGowran 1979b). One miscorrelation of that time, since corrected, was to place the top of the Indo-Pacific stage Te_5 at planktonic foraminiferal zone N8 instead of N6. That error distracted attention from the good record of the spike on the western margin (Chaproniere 1975) if not the southern. Also, Ludbrook's (1961) record of *Austrotrillina* and *Marginopora* in the upper member of the Mannum Formation (western Murray Basin) was overlooked. We have corrected this omission with new records from the Gippsland and western Murray Basins (Fig.4) showing spikes in the abundance of *Operculina* and *Amphistegina* which both seem to be coeval and to correlate with zone N6. It is noteworthy that the facies are contrasting, for that contrast enhances the importance of the signal as a climatic indicator: at Mannum the plankton counts are very low and *Austrotrillina* and *Marginopora* have been recorded whereas the plankton count is higher and the two genera are missing at Lakes Entrance. This event in southern Australia is a much-subdued version of the warming seen in the later Otaian stage in New Zealand, where tropical-type molluscan and larger foraminiferal assemblages appear in the North Island (Hornibrook 1990).

(iii) Earliest middle Miocene, Batesfordian-Balcombian, Zones N8b–N9. This narrow interval contains two immigrations of *Lepidocyclina*, with *Cycloclypeus* in the east and *Flosculinella* in the west in the younger (Fig. 4), suggesting provincialism—the Austral–IndoPacific and the Southeast Australian Provinces (see discussion in Darragh 1985). We have no ready explanation for this provincialism although the large foraminifera are distinguishable ecologically and at least partially distinguishable in their biofacies, as Chaproniere (1975) showed for this region. It is the time of the Batesford-Morgan and the Balcombian marine transgressions and together they display easily the richest warm-water biotic record across southern Australia at the time of maximum Neogene extent of the sea across the continental margins (McGowran 1979a; subsequent discoveries in Lindsay 1981; Benbow and Lindsay 1988). It is the Miocene optimum at the climax of the Miocene oscillation.

The Miocene optimum has been thoroughly confirmed in Japan and north to Kamchatka, on diverse marine and nonmarine biotic criteria (Tsuchi 1992; Itoigawa and Yamanoi 1990; Gladenkov 1990). The 'tropical marine paleotemperature spike at about 16Ma' (Itoigawa and Yamanoi, 1990) centres on Zone N8b but the concentration of data for warming to high northern latitudes is correlated with zones N8–N9. We see it in the early Badenian transgression and warming in central Paratethys (Steininger and Rögl 1983; McGowran 1979b). Emphasized here as the climatic optimum of the Miocene and the Neogene, it is labelled as climatic optimum 1 in the Pacific oceanic record (Barron and Baldauf, 1990). The second major peak in the Shackleton-Kennett $d^{18}O$ curve (Campbell Plateau) falls at the lower level of this bimodal optimum (McGowran 1979a). The peak is seen at just the 'right' level in New Zealand in the latest Altonian and Clifdenian stages (Hornibrook 1978). A more recent review by Hornibrook (1990) repeats the observations that it is in Altonian time that larger foraminifera (*Lepidocyclina, Heterostegina, Cycloclypeus, Planorbulinella zelandica, Amphistegina*) reach southernmost New Zealand; that stenothermal warmwater Indo-Pacific mollusca in the South Island reached maximum diversity (Beu, 1990); and that these records are particularly favoured by the widespread shallow-neritic facies, implying maximum transgression. The Altonian stage extends by correlation from upper zone N6 to about the zone N8a/N8b boundary (Hornibrook *et al.* 1989) but it is clear from Hornibrook's review that the 'thermal maximum' is in the upper Altonian and Clifdenian, i.e. correlated with zones N8–N9.

All of these correlations confirm a distinct peaking of the Miocene oscillation, in a time interval *in toto* of one million years or even less, in the earliest middle Miocene.

[(iv) Late middle Miocene, upper Bairnsdalian, Zone N14 equivalents. Not seen in larger foraminifera in southern Australia, this horizon in the Capricorn Basin and New Zealand was correlated with a *Lepidocyclina* horizon in Japan and perhaps with the early Sarmatian marine transgression of central Paratethys (McGowran 1979a,b). Hornibrook (1990) suggests that this temporary warming followed by the extinction of foraminifera in New Zealand is a possibly significant inter-regional event. At Lakes Entrance we find the horizon as an acme in the planktonic *Globigerinoides sacculifer* in Assemblage XIII

(see below; McGowran and Li 1993).]

The warm horizons are shown in Figure 6.

The section at Lakes Entrance in east Gippsland

The Lakes Entrance oil shaft (Crespin 1947) was the one of the very first sections to contribute to our modern understanding of the southern temperate planktonic foraminiferal succession (Jenkins 1960). In reexamining the section, we have used a range of quantified criteria to distinguish sixteen faunal assemblages spanning some 20 Ma (McGowran and Li 1993). The criteria (Fig. 5) include changes in the relative abundances of five species groups approximating clades, the planktonic/benthic ratio, and species diversity. The ratio of the dominant species in the two dominant groups, (*Globigerina woodi* + *connecta*) ÷ (*Globigerina bulloides*+*falconensis*), is a good index of warmer/oligotrophic to cooler/eutrophic changes (shorthand: *woodi/bulloides* ratio). An interesting plot is the actual comings and goings of planktonic species, sample by sample, thus emphasizing the presence (or absence) of a species, not its local range from lowest to highest record.

As we emphasize elsewhere (McGowran and Li 1993), the section falls into three parts. In descending order:

(iii) Assemblages XI to XVI—collapse of the *woodi/bulloides* ratio; measures return to less feverish levels of oscillation. Zones upper N9–N17 equivalents; Bairnsdalian and Mitchellian.

(ii) Assemblages IX to X—greatest amplitudes in fluctuation in all measures including the *woodi/bulloides* ratio. Zones uppermost N7 to lower N9 equivalents; uppermost Longfordian, Batesfordian, Balcombian.

(i) Assemblages I to VIII—decline in planktonic/benthic; rising trends in the *woodi/bulloides* ratio peaking within the mid-Longfordian warm interval; stability in diversity and in incomings and outgoings. Zones N4 to upper N7 equivalents; upper Janjukian to upper Longfordian.

There is an interesting counterintuitive relationship revealed in Figure 5. The positive spikes in the *woodi/bulloides* ratio probably indicate warmings in the upper water column, given what we know of the modern counterparts. If so, then they should match high points both in the planktonic/benthic ratio and in planktonic species diversity. It is consistently clear, however, that the reverse is the case. We suggest as an *ad hoc* speculation that fluctuations in warming were accompanied by increases in precipitation and runoff from the nearby southeastern highlands,

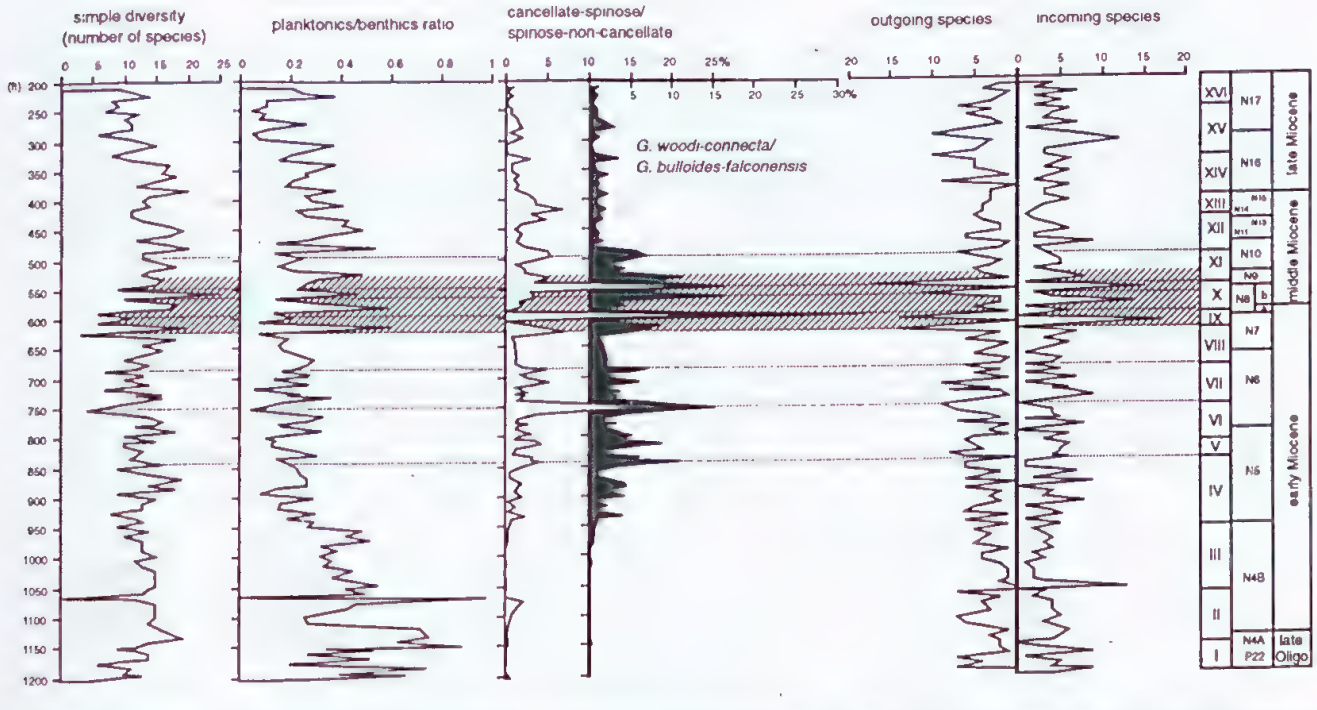

FIGURE 5. Profiles of selected planktonic foraminiferal variables, based on about 15 000 specimens, Lakes Entrance Oil Shaft (McGowran and Li 1993). The *woodi–connecta/bulloides–falconensis* ratio is the dominant component of the cancellate–spinose/spinose–noncancellate ratio. Tie lines emphasize some of the matches, particularly between high *woodi/bulloides*, low diversity and low planktonic/benthic ratio. Hatched interval emphasizes increased oscillations in assemblages IX and X which span the Miocene climatic optimum.

causing briefly an estuarine-type, surface-water outflow, lowering salinity very slightly (planktonic foraminifera are very sensitive to salinity variations) and suppressing both population numbers and taxic diversity. Thus there may be here some evidence of a major increase in precipitation during the climatic optimum, as indeed one would expect.

Correlation: global palaeoceanographic signals

The significance of the Lakes Entrance planktonic foraminiferal succession becomes apparent in the global perspective. Figure 6 displays correlations, independently of each other with the integrated Miocene time scale, of three factors: the Exxon sea level curve (Haq *et al.* 1987); two $d^{18}O$ oceanic profiles which according to Wright *et al.* (1992) reveal glacial fluctuations labelled as the ten *Mi* glaciations; and assemblages I–XVI at Lakes Entrance. Note that at 10^7 years scale there are matches between sea level and palaeotemperature in that both rise to a peak at the optimum, then fall; and at 10^6 years scale there are some matches between glaciation and sequence boundary and some mismatches—a situation that will improve with further scrutiny. Note too that the *Mi* glaciations do not disappear towards the peak of the 10^7 years curve to reappear

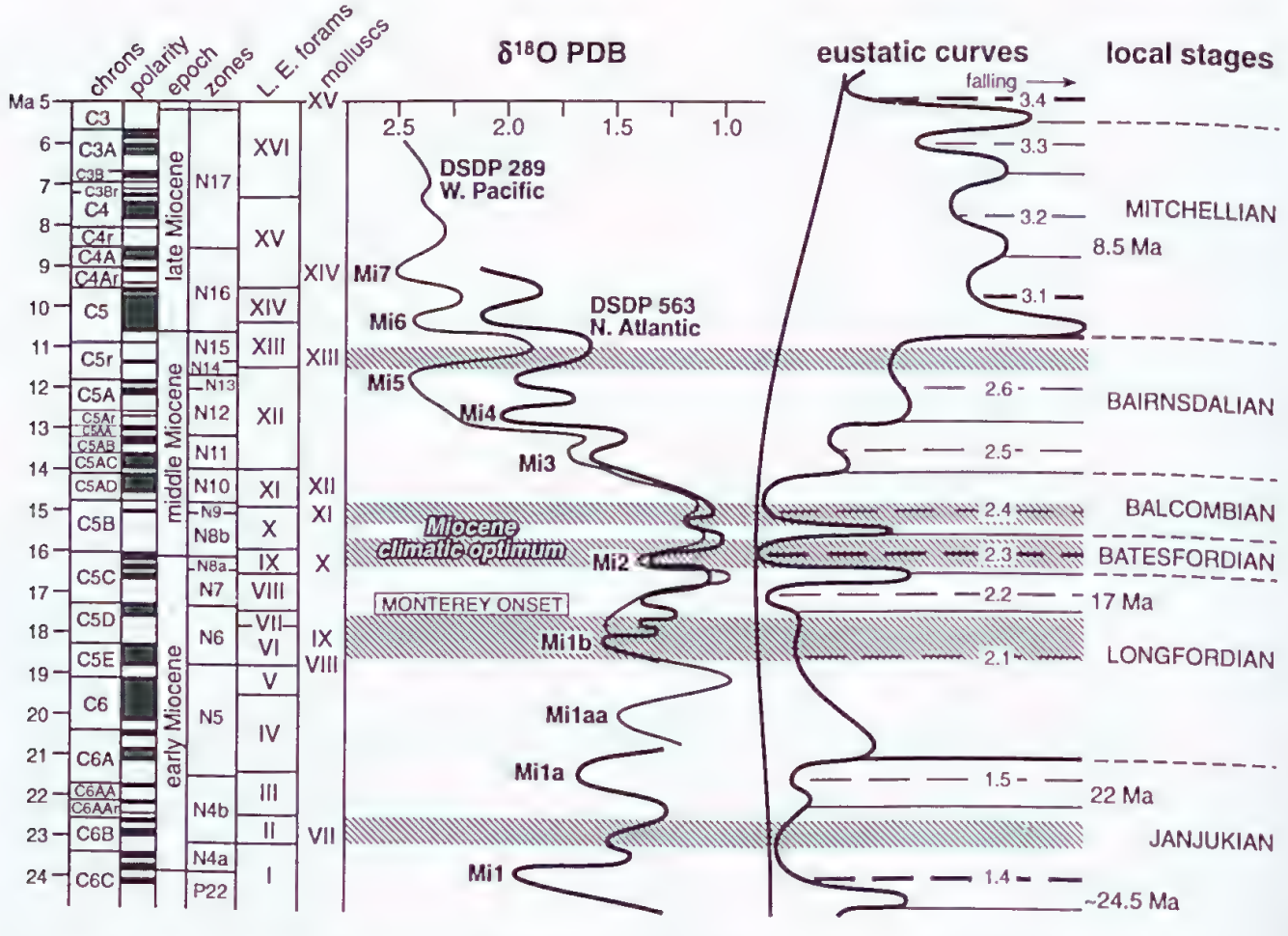

FIGURE 6. Integrated scenario for the Miocene, based on McGowran and Li (1993). Chronology at left, from W. A. Berggren (pers. comm., 1992). Molluscan assemblages VII–XV are from Darragh (1985). The two $\delta^{18}O$ curves were drawn not by us but by Wright *et al.* (1992) by filtering a cloud of points. The long- and short-term eustatic curves are from Haq *et al.* (1987); solid lines, sequence boundaries broken lines, maximum flooding surfaces with third-order sequence notation. Note that those curves and the planktonic foraminiferal assemblages I–XVI from Lakes Entrance in Gippsland ('L.E. forams') are correlated independently with the time scale, not with each other. Fine tuning will improve the match between *Mi* glaciations and sequence boundaries (solid lines). The regional stage boundaries are placed as a suggestion at sequence boundaries (see text) but note that correlation of sequence boundaries with integrated geochronology is far from finally fixed. The three warm intervals recognized on the occurrence of larger foraminifera are shown hatched with the Miocene climatic optimum shown as a double, comprising Batesfordian and Balcombian components.

on the downslope, but *Mi2* is close to the summit. This is consistent with the identification of a marine glacial episode during the peak of the Neogene climatic optimum (=Miocene optimum) (Marincovich 1990). Most interesting of all is the sense of increased perturbation in the various measures in assemblages IX and X—at the zeniths of both climatic and sealevel trajectories and preceding, not accompanying, the major falls! It is the Miocene optimum that displays instability in the fossil record, not the immediately subsequent chilling and regression.

Regional stages?

Palaeontologists have long been aware that the Batesfordian and Balcombian stages mark major changes in the molluscan fossil record. That they also mark very brief ages, became apparent in their first correlation with a modern geochronology (McGowran *et al.* 1971). Although Batesfordian facies commonly are bryozoan limestones and Balcombian are marls and clays, there is more to it than merely facies, as Ludbrook (1973) has pointed out. Darragh's (1985) recognition of nine Miocene molluscan assemblages shows an interesting parallel with the planktonic foraminiferal record (Table 1; Fig. 6). Although the tabulation is incomplete, being of 'key' species selected for biostratigraphic significance and not the entire fauna, it shows a major turnover in the Janjukian (greatly exaggerated by a very poor pre-Janjukian record), followed by strong species incomings in both the Batesfordian and Balcombian with disappearances greatly exceeding new arrivals through the Bairnsdalian, then some recovery—partly facies-controlled—in the Mitchellian. Darragh (pers. comm. 1993) warns that taxonomic turnover would be subdued if the entire assemblages were used, even though his own figure (1985, Fig. 5) gives much the same result. The sense of major molluscan change in the two very short stages at the Miocene optimum deserves study at the full-faunal level.

As stages, erected on molluscan assemblages in neritic facies, become redefined more precisely on planktonic/micropalaeontological criteria (which are external, the organisms having floated in from the ocean), they become rather less useful (Loutit *et al.* 1989). That is because there will always be a problem in recognizing precise bio-events as chrono-events in neritic or paralic facies, where diachronism or erratic preservation and recovery of index fossils are more likely. Instead, suggest Loutit *et al.* we should consider reorganizing stages as depositional sequences, for all strata above a sequence boundary are younger than all strata below it. The notion of 'warm interval' illustrates the problem here. The Janjukian/Longfordian boundary is put at the base of *Globoquadrina dehiscens* which is also close to the first record of the large benthic species *Operculina victoriensis* (Carter 1964, 1990) which is within the warm interval and within 'the difficult transitional period between the Palaeogene and Neogene' (Ludbrook 1973). That necessitated prolonged discussion of the molluscan faunas (Ludbrook 1973) and of the biotic evidence for warming and its chronology (Lindsay 1981), and has contributed to uncertainty in chronology. A possible solution is foreshadowed in Figure 6. It would be better to raise the boundary to the major sequence boundary within the early Miocene so that the macrofaunas and microfaunas could be treated as a unit in local correlation reflecting their unity as a record of the 'warm interval'. That shift upwards would do no violence to boundary stratotypes, for the stratotype Longfordian has no defined lower boundary in

TABLE 1. Nine of the southern Australian molluscan assemblages, with positions in regional stage succession, and first and last appearances of and numbers of 'key species' (i.e. biostratigraphically significant), taken from text and tabulations in Darragh (1985). The assemblages are also shown on Figure 6.

Mollusc assemblage		Stage	First	Last	Total
XV	Bunga Creek	Cheltenhamian	18	10	60
XIV	Rose Hill	Mitchellian	21	5	47
XIII	Lake Bullenmerri	Bairnsdalian	5	41	67
XII	Gunyoung Creek	Bairnsdalian	4	36	99
XI	Balcombe Bay	Balcombian	23	18	116
X	Boornong Road	Batesfordian	25	12	105
IX	Fishers Point	Longfordian	11	10	90
VIII	Jan Juc Beach	Longfordian	9	9	90
VII	Bird Rock	Janjukian	58	34	115

Gippsland and the Janjukian at its stratotype near Torquay has had its upper boundary raised well above the top of the Jan Juc Formation to the bioevent, base *Gq. dehiscens*. Note, however, that that suggestion depends entirely on searching out the sequence boundary 1.5/2.1 in the local strata.

The Longfordian/Batesfordian and Batesfordian/Balcombian boundaries would change little. The Balcombian spans an absurdly brief segment of the *Orbulina* bioseries (Carter 1964) and either it might be subsumed with the Batesfordian as substages of a Balcombian *sensu lato*, as Carter (1990) has proposed, or it could occupy cycle 2.4. The Bairnsdalian/Mitchellian boundary would change little. The point is that the concept of the local or regional stage would change for the better, and they would return to routine and widespread use as natural divisions of the stratigraphic record, should a comprehensive sequence-stratigraphic analysis cogently identify the boundaries. Meanwhile, we emphasize again that the regional stage boundaries shown in Figure 6 are suggestions, not conclusions.

Discussion

The Miocene succession in southern Australia can be compared closely with a global scenario of rising sealevels and temperatures from the latest Oligocene to the early middle Miocene, then a pronounced plunge in both indicators from the early middle Miocene to the late Miocene. The generalized stratigraphic patterns in Figure 2 are in accord with the trends in Figure 6. Superimposed on these broader (10^7 years) trends are the higher-frequency phenomena detected in the oceanic oxygen isotopic record, the third-order depositional cycles, and the local planktonic foraminiferal assemblages—all at *comparable* time scales in the 10^6 year band. But where we find numerous 'warm intervals' in the planktonic foraminiferal *woodi/bulloides* ratio at that frequency, we see only three warm intervals in the Miocene on more comprehensive criteria as well as at a longer time scale. They are in the Janjukian–early Longfordian, the mid-Longfordian, and the Batesfordian-Balcombian, the last being the twin-peaked Miocene climatic optimum. It is likely, but only partly indicated on Figure 6 and yet to be rigorously established, that the mini-glaciations *Mi1a* and *Mi1aa* will fall between the first and second of these warm intervals, and *Mi1b* and *Mi2* between the second and third. When it was warmer, it was wetter, and that too may be seen at the higher frequency in the *woodi/bulloides* ratio.

What have these generalizations to do with the terrestrial biotic record? There are several implications:

(i) The regional patterns have extensive good matches with the global patterns. Therefore, we would be very suspicious of arguments that attempt to contrast a drier interior with a more humid coast, say, or a milder south with a warmer north. It is not that those contrasts did not exist—they did!—but that the chronologies and correlations are too weak to permit separation of lateral contrasts from vertical contrasts. The signals from the oceanic and neritic records will have their counterparts continent-wide in the various components of the environmental mosaic, obscure though they probably are. For example, a warming will be signalled coevally in three ways in three environments—as a $d^{18}O$ negative kick in the oceanic realm, as an immigration from the tropics in the (expanded) neritic realm, and as a change from drier to moister floras in the terrestrial realm.

(ii) However, arguments about environment or evolution have to be at the right time scale and relative ages have to be correct at that scale. If chronological correlations of two faunas or floras are wrong by a million years, then comparisons and contrasts depending on a perceived contemporaneity become nonsensical, because the environment is oscillating at that same scale which is too fast for any generalization to mean anything. There is little to be said about (for example) two 'late Oligocene–early Miocene' faunas in this context because we simply do not know whether they were coeval or not.

(iii) However, more can be said at the longer scale—comparing early-middle Miocene faunas or floras with middle–late Miocene, for example. In 1983–84 there were no Miocene marsupial faunas (other than *Wynyardia*) recognized as being older than Batesfordian in Australia (Woodburne *et al.* 1985). By 1992–93, there had been a substantial downward revision of several, so that the early Miocene and late Oligocene is now populated with assigned terrestrial assemblages (Archer *et al.* 1989, 1994; Rich *et al.* 1992; Megirian 1992; Woodburne *et al.* 1994). That is intrinsically a more likely scenario of age distributions, because it shifts some of the more important terrestrial faunas into *generally* warmer–wetter times, which are more likely to be preserved (and discovered) than are the biotas of cooler–drier times (McGowran 1986b). It is unlikely on predictable environmental grounds that the Riversleigh

assemblages are Bairnsdalian, as Woodburne *et al.* (1985) suggested.

(iv) There has been some disagreement over the broad nature of the Riversleigh environments. The host sediment, the Carl Creek Limestone, has been interpreted as a calciclastic alluvial outwash that could only have accumulated under relatively dry and perhaps even semi-arid conditions (Megirian 1992). That implies to Megirian that the Riversleigh rainforest was merely a refugium and the high mammalian diversities in the Miocene are due to the mixing-in of biotas from much drier distal habitats. Archer *et al.* (1994) advance several ecological and taphonomic arguments against this view and reiterate earlier conclusions that the Riversleigh assemblages represent biotas in low-latitude rainforests. Our emphasis on the distinction between phenomena at 10^7 and 10^6 year scales might point to a resolution of this conflict by accommodating both scenarios at the higher frequency. Thus the preserved faunas might be biased in their age distribution towards the warmer-wetter segments of Longfordian–Balcombian times when the terrain was heavily forested and the limestones were karsted. The sedimentological evidence for the depositional environment of the Carl Creek and equivalent limestones might be biased towards the *Mi* glacial (=cooler/drier) times of the same time span. Several successional and alternating episodes of the contrasting environmental regimes could easily be accommodated within the age range of the Riversleigh.

(v) Those revisions in the correlation and age determination of vertebrate assemblages also accord better with emerging generalizations about Australian floras. Whereas macrofloras are more informative than microfloras as to environment, too often they are poorly constrained in their geological ages, so that an entire discussion can become diffuse as to what happened and just when did it happen (e.g. Hill 1992). On microfloral evidence mostly from the eastern Murray Basin, Martin (1989) concludes that the region largely was forested and mostly with rainforest prior to the middle Miocene. In the middle-to-later Miocene widespread rainforest was extensively replaced by eucalypt wet sclerophyll forest. The extent of moist forest and deep chemical weathering predictably reached their maximum during the Batesfordian-Balcombian climatic optimum. The later Miocene was somewhat drier, and we can now assert that a change toward drier sclerophyll forests would have begun fairly early in the middle Miocene, in the early Bairnsdalian, *sensu* Figure 6. On Martin's recent studies pertaining to the problem of Australian grasslands, Archer *et al.* (1994) comment: 'On balance, there is no evidence for early to mid Miocene grasslands in Australia'—a generalization that has the right 'feel' about it from our standpoint. The subsequent change in vegetation also entails a change towards sparser records, and records that are harder to date with confidence and precision.

The Monterey effect?

Why did the world warm up through the early Miocene, teeter on the brink for about a million

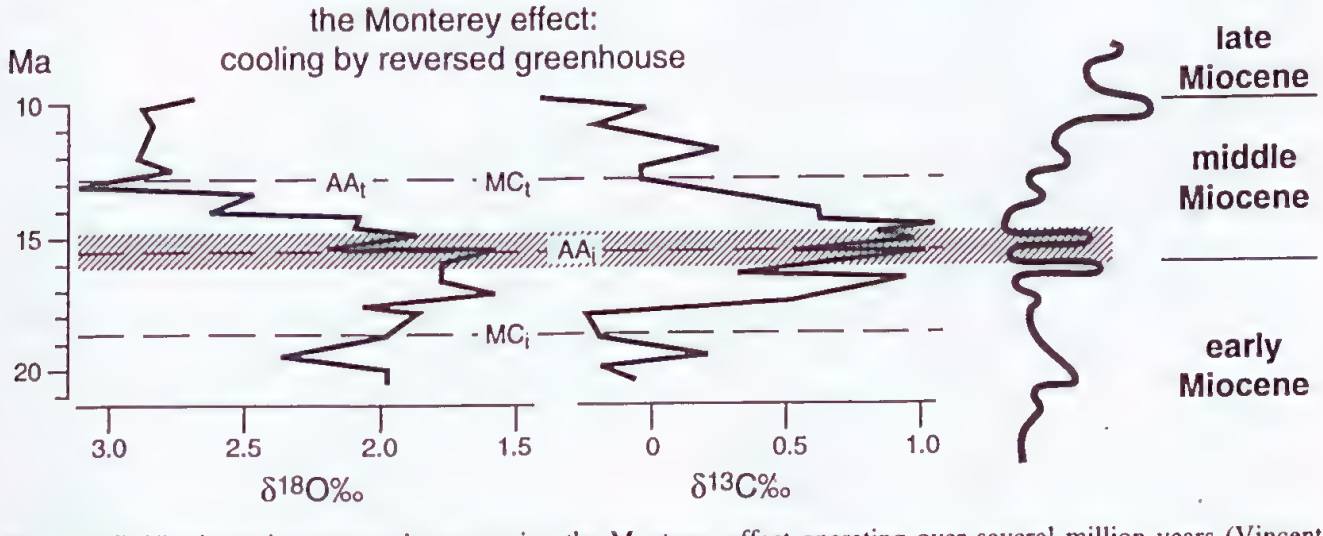

FIGURE 7. The isotopic patterns demonstrating the Monterey effect operating over several million years (Vincent and Berger 1985). MC$_i$, MC$_t$, Monterey carbon event, initiation and termination. AA$_i$ AA$_t$, Antarctic ice buildup, initiation and termination. Eustatic curve as for Figure 6. Hatching shows the Miocene climatic optimum, identified on other grounds (see text and Figures 5 and 6) but most importantly fitting the pattern very well by correlation.

years, then plunge toward the chilly state of the late Neogene, never again to attain that greenhouse state of fifteen million years ago? The Monterey hypothesis of Vincent and Berger (1985) still fits the record well. It is a pattern hypothesis in which the profiles of $d^{13}C$ and $d^{18}O$ reveal cause and effect (Fig. 7). A pronounced positive trend in $d^{13}C$ beginning at horizon MC_i was found in both surface and bottom oceanic successions, suggesting removal of light carbon from the oceanic reservoir (such as into the organic-rich Monterey Formation and its circum-Pacific equivalents). At a critical point, the $d^{18}O$ trend, strongly negative, went suddenly into the opposite direction, indicating growth of the Antarctic icecap and chilling of the global bottom waters at a CO_2 drawdown, a threshold in reversed-greenhouse (AA_i). The event concluded after about 5m.y. at horizons MC_t, AA_t. It all fits very well chronologically with the Miocene climatic optimum with its attendant evidence from sea level and the fossil record.

Acknowledgments

The work was supported by an Australian Research Council Fellowship. We thank Michael Archer for a most useful preprint and, together with several other members of the vertebrate palaeontological community, for encouraging the preparation of this paper. He and Tom Darragh reviewed the manuscript and their comments were helpful. Bill Berggren generously supplied a copy of an unpublished Miocene time scale.

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WORLD HERITAGE AND FOSSILS

The purpose of this paper is to give a broad overview of the World Heritage Convention, to explain Australia's participation and to give details of the first Australian Fossil Site nomination: Murgon, Riversleigh and Naracoorte.

The Convention Concerning the Protection of the World's Natural and Cultural Heritage, known as the World Heritage Convention, was adopted by the UNESCO General Conference in 1972. In 1974, Australia became one of the first signatories. Since then, the number of countries that are party to the Convention has risen to 132.

The World Heritage Convention aims to promote co-operation among nations to protect worldwide heritage which is of such universal value that its conservation is a concern of all people. It is intended that, unlike the seven wonders of the ancient world, properties will be conserved for all time. Member countries commit themselves to ensuring the identification, protection, conservation, presentation and transmission to future generations of their World Heritage Properties. These ideas form the very backbone of the Convention.

The Convention establishes the World Heritage List, which identifies natural and cultural properties considered to be of outstanding universal value, and, by virtue of this quality, especially worth safeguarding for future generations. In order to qualify for inscription on the World Heritage List, a nominated property must meet specific criteria and integrity conditions from either a natural or cultural point of view.

The world's natural heritage offers a priceless legacy. It includes sites representing major stages in the geological and biological history of the earth; outstanding examples of significant ongoing processes; areas of exceptional natural beauty; and significant natural habitats for the conservation of biodiversity. Examples of natural properties include Sagarmatha National Park in the Himalayas of Nepal and Iguacu National Park, a cross border listing shared by Brazil and Argentina.

Cultural heritage sites are equally priceless. Certain archaeological sites, groups of historic buildings, ancient towns, monumental sculptures and paintings whose significance transcends political or geographical boundaries constitute part of this irreplaceable heritage. Some of these treasures represent unique artistic achievements and masterpieces of the creative genius; others have exerted great influence over a long period of time or within a cultural area of the world. Some may be the unique witness to a civilisation which has disappeared or to a type of settlement that has become vulnerable under the impact of change. Others may be associated with ideas or beliefs that have left an indelible mark on the history of humanity. Cultural heritage covers a wide range of properties, including the Tassili n'Ajjer in Algeria and the Vezelay Abbey in France.

A World Heritage Property can be listed for both natural and cultural values. Even so, the division between natural and cultural properties is somewhat artificial, and in the last year has been addressed to some extent with the addition of cultural landscapes as a group over the middle ground.

An essential characteristic of the World Heritage properties is their variety: without the multiplicity of animal and plant species and the diversity of ecosystems, without the distinctive contributions of every culture and every people, the immense tapestry would remain incomplete.

To date, Australia has ten World Heritage properties, which all contribute significantly to the wealth of the tapestry. Australian World Heritage properties read like a travelogue of our most spectacular and unique places and include:

- the Great Barrier Reef
- the Willandra Lakes Region
- the Lord Howe Island Group
- Uluru National Park
- the Wet Tropics of Queensland
- East coast temperate and subtropical Rainforest parks
- the Tasmanian Wilderness
- Shark Bay
- Kakadu National Park
- Fraser Island.

All of Australia's properties have been listed for their natural values and are generally very large. We have the honour of having four properties listed on all four natural criteria, and three listed for both natural and cultural criteria. This puts our properties into a very elite group.

Australia has been very active in the World Heritage field, not only with the listing of our properties, but also with their protection. In 1983, the Commonwealth Government enacted the *World Heritage Properties Conservation Act*, which provides for the protection and conservation

of World Heritage Properties in Australia and its external territories.

There are now 380 sites on the World Heritage List, which includes several fossil sites:

- the Burgess Shale site in Canada,
- the Dinosaur Provincial Park in Canada,
- and Olduvai Gorge in Tanzania.

Australia has a fossil record of great antiquity, extending from 3.5 billion years ago to the present.

On 21 December 1992, the Prime Minister, Mr Keating announced in his Environment Statement that the fossil sites at Riversleigh and Naracoorte would be nominated to the World Heritage List in 1993. The Murgon Fossil site will also be included in the nomination. Agreement has been reached with the South Australian and Queensland Governments to proceed with the nomination.

The three sites represent three key stages in the evolution of our unique Australian fauna over the last 55 million years.

The marsupial fossils from Murgon include a diverse suite of primitive forms, some of which appear to more closely resemble extinct South American marsupials than any previously known from Australia. Besides marsupials, many other discoveries have been made, including the tiny tooth of a very small placental mammal, which is challenging understanding about the evolutionary and biogeographic history of this region of the world. The site is about 55 million years old, and is the only link between the opalised monotreme jaw from Lightning Ridge in NSW and younger mammal deposits.

The Riversleigh deposits date from 25 million years old to the present, and occur in unique freshwater limestone. With more than 20 000 specimens representing 150 faunal assemblages, Riversleigh has lead to an understanding of how the environment and the animals that lived in it have changed over time from a rich rainforest community to a semi-arid grassland.

The fossil bed and Ossuaries of Victoria Fossil Cave at Naracoorte contain the remains of at least 93 vertebrate species, ranging from tiny frogs to buffalo sized marsupials. This makes it one of the richest Pleistocene marsupial fossil deposits in the world. The sediments accumulated between 170 000 and 18 000 years ago and therefore over two of the Pleistocene glacial periods.

As the sites occur in two different States, the Commonwealth Government is responsible for preparing the nomination documents in close consultation with the States involved. Nominations must be submitted to the UNESCO secretariat in Paris – by 1 October each year. They are then referred to the World Heritage Bureau (the executive of the Committee) and thoroughly assessed. The Bureau is assisted in this task by IUCN – the World Conservation Union which advises on natural sites and ICOMOS which advises on cultural sites. In addition, these organisations consult with relevant experts around the world.

The evaluations are considered by the Bureau at their meeting in the year following the submission of the nomination, and a recommendation on the listing of the property is made to the World Heritage Committee. The Committee consists of 21 nations and represents the different regions and cultures of the world. It considers the recommendations from the Bureau and the evaluation from IUCN or ICOMOS and decides whether the property will be inscribed.

For the Australian Fossil Sites nomination being prepared this year, this timetable will mean the nomination is submitted by October 1993, assessed in early 1994, considered by the Bureau in June 1994 and a decision made by the World Heritage Committee in December 1994. As can be seen, World Heritage Listing is not an instant process and usually takes about two years to complete.

This fossil sites nomination seeks to tell a story of change over time, rather than just providing a snapshot of the sites. There is potential if this nomination succeeds, to nominate further sites that fill out the story of mammal evolution in Australia, or tell other unique stories of universal value. World Heritage attracts a lot of attention, and the 1993 nomination of Australian Fossil Sites will increase worldwide awareness of our unique Australian history.

Mary JINMAN, World Heritage Unit, Department of Environment, Sport and Territories G.P.O. Box 787, Canberra, Australian Capital Territory 2601. *Rec. S. Aust. Mus.* **27**(2): 213–214, 1994.

PROTECTION OF MOVABLE CULTURAL HERITAGE

The Commonwealth *Protection of Movable Cultural Heritage Act 1986* was enacted in 1986 and brought into operation in 1988. The principal goal of the program is, as stated in November 1985 in the Federal Parliament by the then Minister for the Arts, Heritage and the Environment, the Hon. Barry Cohen MP, 'to protect Australia's heritage of cultural objects and to extend certain forms of protection to the cultural heritage of other nations' through controls on the export and import of significant movable cultural heritage objects. A closely related goal was to enable Australia to accede to the 1970 UNESCO Convention on the Means of Prohibiting and Preventing the Illict Import, Export and Transfer of Ownership of Cultural Property.

Probably the most important aspect of the Act is the National Heritage Control List, which defines the categories of movable objects that are classed as 'Australian protected objects'. The Control List includes Class A objects which cannot be granted a permit for export and Class B objects that may be granted a permit for export.

Class A objects include some of the most significant items of Aboriginal heritage:

- bark and log coffins;
- human remains;
- rock art; and
- dendroglyphs (carved burial and initiation trees).

Class B objects include:

- archaeological objects;
- other objects of Aboriginal heritage;
- archaeological and ethnographic objects of non-Australian origin;
- natural science objects of Australian origin;
- objects of applied science or technology;
- military objects;
- objects of decorative art;
- objects of fine art;
- books, records, documents, graphic material and recordings;
- numismatic objects;
- philatelic objects; and
- objects of social history.

The Control List also sets out the particular criteria defining 'Australian protected objects' in each category controlled under the Act. Generally the criteria include historical association, cultural significance to Australia, representation in an Australian public collection, age and current Australian market value.

The Act also provides for the establishment of the National Cultural Heritage Committee whose main function is to advise the Minister on the operation of the Act. The Committee consists of ten people of whom four represent collecting institutions, four have experience relevant to the cultural heritage of Australia, one is a nominee of the Minister for Aboriginal Affairs and one is a member of the Australian Vice Chancellors Committee.

The day-to-day administration of the Act is carried out by the Cultural Heritage Branch of the Department of the Arts and Administrative Services. The most common aspect of the administration of the Act is the process for the issuing of export permits.

It is important to stress that within each category there is a definition of whether or not the item comes under the Act. For example, a palaeontological object must have an Australian market value of more than $1 000 before it comes under the Act. Similarly, a mineral must have a value of $10 000. However all meteorites and australites are covered under the Act. In many cases, the item does not come under the Act. If, however, the item is a 'protected object' it will be necessary to obtain the relevant form from the Branch for the export of the item.

When the completed form is returned to the Branch, it is then sent to Expert Examiners who assess the application. These examiners are usually from collecting institutions who have a good knowledge of the item in question and similar items elsewhere in the country. The reports from the Expert Examiners are then forwarded to the Committee for consideration. The Committee, in turn, makes its recommendation to the Commonwealth Minister–at present, Senator the Hon. Bob McMullan–who duly decides on whether a permit should be granted. One important point to note is that the Committee does not have to abide by the reports from the examiners and the Minister does not have to accept the Committee's recommendation, i.e. the Minister makes the decision. The time taken for this process can range from a few days to few months, particularly if the item is of major significance.

To date, over 160 applications for an export permit have been received by the Department and only one item, a painting, 'The Bath of Diana', has been refused an export permit.

One other important aspect of the Act of interest to palaeontologists is the topic of illegal exports.

The export of fossils with a value of $1 000[§] or more from Australia is prohibited under the Act if a permit has not been obtained. The maximum penalty for this offence is a $100 000 fine or imprisonment for five years, or both.

Following a request from this Department in mid-1991, the Australian Federal Police began inquiries into the alleged theft of Ediacaran fossils from South Australia. These inquiries resulted in the identification of a number of suspects. The investigation also identified further sites in South Australia and Western Australia where fossils had been removed and in late October 1991, the Australian Customs Service in Perth intercepted a suspect allegedly attempting to smuggle fossils out of the country. A number of fossils were seized which police believe were intended for sale on overseas markets. The police are continuing their inquiries and some fossils which have been illegally exported have been returned to Australia. It is not possible to provide all the details of this case as the investigation is still to be finalised.[§]

A review of the Act was conducted recently to evaluate the efficiency and effectiveness of the cultural heritage export and import control program, established by the Act and Regulations. The review report was released as a discussion paper. Government departments and authorities, interested organisations and the general public were invited to comment on the report and its recommendations and ninety-two submissions were received. The major issues addressed in the report included:

- publicity for the scheme;
- devolution of the centralised system of administration of the scheme to the collecting institutions in the States and Territories;
- amendments to the Control List including the creation of a 'National Register';
- overcoming the lack of money in the National Cultural Heritage Fund.

A total of 60 recommendations were made in the report, some of which require changes to the Act. Of particular interest to palaeontologists is the recommendation to remove the $1 000 minimum market value on palaeontological objects. If accepted, this will mean that all fossils will come under the ambit of the Act. A report will be presented very shortly to the Minister which addresses these recommendations in terms of the public response, the views of the Committee and the department perspective. Depending on ministerial decisions, there may be some amendments to the Act and some changes to the administration of the scheme.

Movable cultural heritage is a complex topic. There is a need for the Act to be administered in a very understanding way and for policies to be developed which reflect current trends and financial positions. However, it could be considered that awareness of the scheme by individuals as well as collecting institutions is the most important issue that needs to be addressed. In this regard, a mailing list is being compiled of all those with an interest in this topic.

With an increasing awareness of the scheme, we are confident that there will be an increasing awareness of the value of our cultural heritage, including our palaeontological heritage.

Phil CREASER, Cultural Heritage Branch, Department of the Arts and Administrative Services, G.P.O. Box 1920, Canberra, Australian Capital Territory 2601. *Rec. S. Aust. Mus.* **27**(2); 215–216. 1994.

[§] On 3 August 1993, the Regulations under the Act were amended and the $1 000 minumum value for palaeontological objects was removed. This means that a permit is required before any fossil secimen is exported. Following a Cabinet reshuffle on 28 January 1994, the Hon. Michael Lee, Minister for Communications and the Arts, assumed responsibility for the Act and administration of the scheme. At that time, the number of applications for permits had increased to more than 220 with the majority of recent applications being for fossils. In addition, one further item, an historic steam engine, has been refused an export permit.

ABSTRACTS OF THE FOURTH CONFERENCE ON AUSTRALASIAN VERTEBRATE EVOLUTION, PALAEONTOLOGY AND SYSTEMATICS, ADELAIDE, 19–21 APRIL 1993

In pursuit of the peregrinating Patagonian platypus

ARCHER, M., GODTHELP, H., MUIRHEAD, J., NOCK, C. & AUGEE, M. 1994
School of Biological Sciences, University of New South Wales, Kensington, New South Wales, 2033.

Discovery in late 1990 of a single upper molar of an early Paleocene monotreme by palaeontologists from the University of La Plata (including Rosendo Pascual and Edgardo Ortiz Jaureguizar) led to the description of *Monotrematum sudamericanum* (Pascual *et al.* 1992). An invitation from the Argentinians to mount a joint expedition from the University of New South Wales was taken up with the aid of a substantial financial grant from the Australian Geographic Society and equipment donated by Paddy Pallins of Sydney. In November and December 1992, we combined efforts to investigate early Paleocene Banco Negro Inferior exposures at Punto Pellegro north of Comodoro Rivadavia, Argentina. The results were highly successful. In addition to more ornithorhynchid material, marsupials, condylarths, engimatic mammals and colossal leptodactylid frogs were found on eroded surfaces and in quarries. Exploration of late Mesozoic to Oligocene sediments in the Grand Baranca, near Sarmiento (west of Rivadavia Comodoro) was equally productive and provides, with the Punto Pellegro deposits, a significant opportunity to expand understanding about the earliest Cainozoic mammal record of South America.

Australian VP bibliography computer data base

BAYNES, A. 1994
Department of Earth and Planetary Sciences, Western Australian Museum, Perth, Western Australia 6000.

The first version of the VP bibliography computer data base was created by combining the Australian mammal chapter bibliography and appendix (in which mammal genera are indexed to the papers) from the then-unpublished *Vertebrate Palaeontology of Australasia*. It is available in Macintosh and PC versions, and its purpose is to answer the question 'What is the literature on genus *x*?' It was offered free on a flyer in *VP of Australasia*. The response was, frankly, lousy. Undismayed, I am expanding it into the MARB (Mammals Amphibia Reptiles & Birds) Australian VP bibliographic data base. In MARB both the process of extracting references to a mammal genus and the indexing of mammal genera mentioned in a paper are simpler. Such a data base can potentially be perfected for the older references with complete generic indexing, and the references can always be cited without error. It can also be kept up-to-date much more easily than a reference book. By CAVEPS, MARB will include the papers but not the indexing of the ARB genera. For these expert help is needed. Graduate students probably represent the best source of manpower for completing the indexing and adding new references, as they will be making the greatest use of the data base. I am hoping someone else will do one on fossil fish, which I know nothing about.

The MARB data base was demonstrated at CAVEPS 93. Copies are available: free to those who contribute to it; $10.00 (or $11.00 including the disk) for others.

Preliminary anaylsis of mammals from Allens Cave, southern Nullarbor

BAYNES[1], A. & WALSHE[2], K. 1994
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2. Department of Archaeology and Anthropology, The Faculties, Australian National University, Canberra, Australian Capital Territory 2601.

Archaeological excavations made in Allens Cave in 1989 yielded substantial quantities of bones. Those from pit E4 (1 m^2) have been analysed. The stratigraphy consists of a basal orange unit 1.9 m deep terminating in a gravel lag deposit that marks a disconformity; above this is a 1.4 m dark grey unit. Two radiocarbon dates have been obtained: 3 720 ± 150 yrs BP at about 1.1 m depth and 5 860 ± 430 yrs BP at the base of the dark grey unit. The orange unit is currently undated, but probably late Pleistocene in age. Remains of large mammals are generally highly fragmented; those of the smaller mammals are dissociated but more complete. Burnt bone is present at all levels. These observations suggest that the principle agents of accumulation were owls (*Tyto* spp.), devils and humans. In the orange unit the contribution from devils and humans predominated; in the dark-grey unit there is more substantial owl prey component.

The mammal fauna of the orange unit is restricted to species whose original distributions include the most arid parts of modern Australia. Above the disconformity species richness increases with the addition of some arboreal species and a substantial south-western element, but few losses. These faunas suggest very arid conditions at the time of deposition of the orange unit and higher rainfall during deposition of the dark grey unit. This is consistent with vegetation changes inferred from palynological investigations of this and other southern Nullarbor deposits.

Responses of mammalian communities to late Quaternary climatic changes

BAYNES[1], A. & WELLS[2], R. T. 1994
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2. School of Biological Sciences, Flinders University of South Australia, Bedford Park, South Australia 5042.

Compared to North America, Australia still has very few windows opened on what was happening to mammalian communities in the geologically recent past. The principal southern and western sites are Devils Lair and Skull, Hastings, Allens, and Victoria Caves. All analysed large stratigraphically discrete samples of mammals show log-normally distributed rank-abundance distributions, indicating that a number of communities has been sampled by agents accumulating remains in the caves, as would be expected. In only one or two cases has an attempt been made to resolve the mammals from a deposit into their contemporary communities; the other sites merely provide assemblage data. The small to medium-sized mammal assemblages from the sites reflect different species equilibria in local mammal communities at different times in the glacial–interglacial cycle. The sites in temperate and semi-arid areas show greater species richness in glacial age deposits than in later Holocene deposit the so-called disharmonious assemblages effect. In marked contrast, in Allens Cave, located on the edge of the modern arid zone but close to the Southern Ocean coast, the higher species richness is in the Holocene levels. This pattern is consistent with the idea that species richness is higher at times of more equable climates. As climates become more equable increasing numbers of species appear to have been integrated into more complex communities. As climates changed in the opposite direction faunal segregation has resulted in simpler communities. The general pattern is also consistent with a centrifugal movement of faunas in response to extremes of continental glacial aridity.

New species of *Nambaroo* (Flannery and Rich) from Riversleigh, northwestern Queensland.

COOKE, B. N. 1994
School of Life Science, Queensland University of Technology, Brisbane, Queensland, 4001.

New species of *Nambaroo* (Flannery and Rich, 1986) are described from a variety of sites of estimated early to mid-Miocene age from Riversleigh deposits of northwestern Queensland. The new species are phenetically similar to those described by Flannery and Rich (1986) from the mid-Miocene Namba Formation of South Australia. Their lower molar morphology supports the views of those authors regarding the evolution of the hypolophid and posterior cingulum among macropodids.

Pliocene whales and dolphins (Cetacea) from the Vestfold Hills, Antarctica

FORDYCE[1], R. E. & QUILTY[2], P. G. 1994
1. University of Otago, Dunedin, New Zealand.
2. Australian Antarctic Division, Kingston, Tasmania, 7050.

Early Pliocene cetaceans from Marine Plain, Vestfold Hills (68°35'S, 78°00'E), are the only fossil higher vertebrates known so far from the Antarctic Oligocene-Pleistocene. Of these, one (possibly two) undescribed extinct species of dolphin (Odontoceti: Delphinidae: new genus) is known from skulls, mandibles, ear bones, and post-cranial elements from three individuals. Skull bones have contact relationships similar to those in other delphinids, but skull topography is remarkably convergent with some extant toothless beaked whales in the genus *Mesoplodon* (Odontoceti: Ziphiidae): the narrow rostrum is toothless, there is a prenarial basin, and the premaxillae carry flat vertical flanges beside the nares. The dolphins seems too derived to be ancestral to any extant species; otherwise, relationships to extant delphinids are uncertain. The shallow marine depositional setting at Marine Plain cautions against but does not preclude ziphiid-like habits (pelagic, deep-diving, semi-solitary, squid-eating) for the dolphin.

Of other specimens, an articulated series of large vertebrae is probably from a baleen whale (Mysticeti). A small right whale (Mysticeti: Balaenidae: genus and species uncertain) has a narrow and ventrally curved but otherwise poorly preserved rostrum and a fragmentary braincase. Ear bones from this specimen, when fully prepared, should better reveal relationships. The fossils are unexpected in that small dolphins (or small ziphiids) and small right whales appear ecologically insignificant in near-shore modern Antarctic waters. Indeed, late Neogene Cetacea elsewhere include bizarre forms and/or unusual distributions, as well as species and distributions of modern aspect. These unusual taxonomic and ecological patterns apparently did not persist into the Pleistocene, which suggests a later Pliocene shift in global cetacean ecology.

Cuddie Springs: new light on Pleistocene megafauna

FURBY[1], J. & JONES[2], R. 1994
1. School of Geography, University of New South Wales, Kensington, New South Wales, 2033.
2. Department of Palaeontology, Australian Museum, Sydney, New South Wales, 2000.

The faunal list for the Cuddie Springs site (compiled after excavations in 1993) has been expanded to include an additional 11 taxa following excavations during 1991. Pollen and sediment analysis has provided a palaeoenvironmental record spanning the late Pleistocene, including the period when the megafauna disappeared. The vegetation history from Cuddie Springs has a time depth not previously recorded from arid–semi-arid contexts. Archaeological material at depth was first documented in the recent excavations with aboriginal stone artefacts occurring in direct association with bones of *Genyornis, Diprotodon* and *Sthenurus*, dating to about 30 000 years B.P. The faunal record is continuous to at least five metres depth and one of the aims of ongoing research is to document the changes in the faunal assemblage through time in an environmental context.

Some rodents from the Pleistocene fluviatile deposits of the eastern Darling Downs, Queensland

GODTHELP, H. 1994
School of Biological Sciences, University of New South Wales, Kensington, New South Wales, 2033.

Sediments collected from several sites on the Eastern Darling Downs were washed and sorted. The fossilised remains of many vertebrates were recovered. The assemblages were dominated by the remains of murid rodents; 8 taxa are recognised. One taxon is as yet unidentified and may represent a new species of *Pseudomys*, the remaining are all extant species. *Mastacomys fuscus* and *Pseudomys higginsi* are recorded from Queensland for the first time.

A new species of the murid Zyzomys from the Pliocene Rackhams Roost Deposit, northwest Queensland

GODTHELP, H. 1994
School of Biological Sciences, University of New South Wales, Kensington, New South Wales, 2033.

A new species of the murid *Zyzomys* is described on the basis of fossil material from Rackhams Roost, a Pliocene *Macroderma* roost site on Riversleigh Station. This species is dentally the most primitive of all known species of rockrats. It is the most abundant mammal species in the deposit. There is a similarly high abundance of *Zyzomys* species in more recent *Macroderma* deposits.

Temporal fenestration in a procolophonid reptile

HAMLEY, T. & THULBORN, T. 1994
Department of Zoology, University of Queensland, Queensland, 4072

The Late Permian and Triassic procolophonids were late survivors from the initial radiation of amniotes, and their skulls are usually thought to have retained the primitive anapsid condition, without temporal openings. However, two skulls attributed to *Procolophon trigoniceps*, from the Lower Triassic of South Africa, have been found to possess a lower temporal opening resembling that of the synapsid reptiles. The temporal opening was first discovered by H. G. Seeley 120 years ago, but its existence has been overlooked or denied in palaeontological literature for the past 90 years. Rediscovery of the temporal opening prompts us to examine the possible affinities of procolophonids and other 'parareptiles'. In doing so, we find no substantial support for the recent suggestion that procolophonids are the sister group of turtles.

Morphological changes in the Australian *Macroderma* lineage (Microchiroptera: Megadermatidae) from the Oligo-Miocene to the present

HAND, S. J. 1994
School of Biological Sciences, University of New South Wales, Kensington, New South Wales, 2033.

From the Riversleigh Tertiary deposits, eight megadermatids belonging to two lineages are now known. Morphological changes in the Australian *Macroderma* lineage are traced from the Oligo-Miocene to the present and comments are made on broader aspects of megadermatid evolution. In some Riversleigh deposits, there is evidence for sympatry of very differently-sized megadermatids. The Riversleigh megadermatids have provided an opportunity to trace an apparent trend to shorten the face in the *Macroderma* lineage from the Oligo-Miocene to the present and to examine a tendency to gigantism in independent megadermatid lineages.

A new and distinctive Oligo-Miocene hipposiderid (Microchiroptera: Hipposideridae) from Riversleigh Station, Queensland

HAND, S. J. 1994
School of Biological Sciences, University of New South Wales, Kensington, New South Wales, 2033.

A large, new and very distinctive hipposiderid is described from complete skull material recovered from the Oligo-Miocene Bitesantennary cave deposit located on the south-eastern margin of the D-Site Plateau, Riversleigh Station, north-western Queensland. The species is compared with Tertiary French and Australian species of *Brachipposideros* as well as Quaternary Australian hipposiderids (genera *Rhinonicteris* and *Hipposideros*). The phylogenetic relationships of the new bat and apparent problems in current hipposiderid taxonomy are discussed.

Scaly-foots and pointy teeth: pygopod mandibular variation and first fossil record from the Miocene of Queensland

HUTCHINSON, M. N. 1994
South Australian Museum, Adelaide, South Australia, 5000.

The snake-like pygopod lizards are a group of 35 species confined to Australia and New Guinea. They are gekkonoid, but their phylogenetic relationship to typical geckoes is not yet well established. Recent morphological and emerging biochemical data point to a sister group relationship with, or possibly within, the Australian diplodactyline geckoes. Pygopods show considerable variation in mandibular and dental structure, correlated with dietary specialisation in several genera. This variation is summarised and employed in identifying the first fossil member of the family to be reported, a partial dentary, from the early Miocene of the Riversleigh area, northwestern Queensland, Australia. The fossil is most similar to the living genus *Pygopus* but differs in its more evenly-sized teeth.

The Neogene radiation of Australian sharks: real or apparent ?

KEMP, N. R. 1994
Tasmanian Museum, Hobart, Tasmania, 7000.

By the Mid-Tertiary all eight orders of Neoselachians – modern sharks – were represented in Australia. Numerically, the Lamniformes (mackerel sharks) dominate the Tertiary record. The Palaeogene is well represented by the Odontaspididae and the Mitsukurinidae, by *Carcharias* (grey nurse sharks) and *Scapanorhynchus* (goblin sharks), respectively. The Odontaspididae continue through to the Recent with large numbers of teeth being preserved, especially in the Neogene. However, the Lamnidae dominate the Neogene in the number of species, with up to a dozen taxa representing at least four genera: *Carcharodon* (white pointers), *Carcharoides* (serrated porbeagles), *Isurus* (makos) and *Lamna* (porbeagle). The presence of at least seven species of *Isurus* in Australia in the Neogene may be indicative of a southern centre of radiation for this genus; nowhere else do all these species occur together. The Carcharhiniformes (ground sharks) which today contain, world-wide, more than half of all shark species are relatively poorly represented in Australian Neogene deposits, and are conspicuous by their virtual absence from the Palaeogene. Of this order, *Carcharhinus* (whalers) is the most common taxon, followed by *Galeocerdo* (tiger shark), *Galeorhinus* (school shark), *Hemipristis* (snaggletooth shark), and *Sphyrna* (hammerhead sharks) which is known from only a few teeth. The Hexanchiformes (six- and sevengill sharks), Pristiophoriformes (saw sharks), Heterodontiformes (bull sharks) and Orectolobiformes (wobbegongs) are known variously throughout the Tertiary, but are certainly not common. The Squaliformes (dogfish sharks) have yet to be found. The influence of the warmer Miocene temperatures – which would be expected to result in an increase in the number and variety of sharks in southern Australian seas is not reflected in the local fossil record. The presence in the Australian Neogene of many species of *Isurus* is real, the numerical dominance of *I. hastalis* is due to a collecting bias, *Carcharias* is definitely a common taxon. The relative paucity of most other shark taxa may be due to depositional features such as fossiliferous winnowed deposits, and lack of preservation of certain environments of deposition.

Studies of the Late Cainozoic diprotodontid marsupials of Australia 1. Revision of the genus *Euowenia*

MACKNESS, B. 1994
School of Biological Sciences, University of New South Wales, Kensington, New South Wales, 2033.

Species of the genus *Euowenia* are rare taxa in Australian faunal assemblages. Two species have been described: *Euowenia grata* (De Vis 1887) on the basis of a partial cranium and dentary from Chinchilla, Queensland and *E. robusta* (De Vis 1891) from dentaries found at Freestone Creek, near Warwick, Queensland. Woods (1968) suggested that *E. robusta* was a junior synonym of *Nototherium inerme*. Mackness (1988) identified *E. robusta* as a zygomaturine and this taxonomic assessment is confirmed here. A number of additional specimens of *Euowenia* have been recovered from northern Australia including a new species, described here on the basis of a partial cranium and lower dentary featuring relatively unworn teeth. This additional material has highlighted a number of useful synapomorphies for *Euowenia* and a new generic diagnosis is provided. Additional published records of *Euowenia* are examined in the light of this new diagnosis. A significant extension in range and chronology is reported. A guide to identifying isolated *Euowenia* teeth from those of other northern Australian diprotodontids is also provided. The late Miocene *Meniscolophus mawsoni* is shown to share many synapomorphies with the genus *Euowenia* and a new taxonomic position is proposed for this taxon.

Studies of the Late Cainozoic diprotodontid marsupials of Australia 2. The identity of *Zygomaturus macleayi* Krefft and *Z. creedii* Krefft

MACKNESS, B. 1994
School of Biological Sciences, University of New South Wales, Kensington, New South Wales, 2033.

A partially reconstructed palate with left and right P^3–M^5 was described from the Condamine River, Queensland by Krefft in Longman (1921) as *Zygomaturus macleayi*. Longman recognised that the P^3 of *Z. macleayi* was not the same as *Z. trilobus* but could not make any definitive taxonomic assignment. It is confirmed here that the holotype does not represent a zygomaturine based on its P^3 morphology. Another right P^3–M^5, figured by Owen (1872) as *Nototherium inerme* and a cast of a left P^3–M^5 (BMNH M5002 labelled *Nototherium mitchelli* although presumably from the same animal) represent additional specimens referable to *Zygomaturus macleayi*. Woods (1968) suggested that the identification of the Owen illustration as *Nototherium inerme* was correct. This cannot be the case, however, as the molar row gradient of *Zygomaturus macleayi* is substantially different to all *Nototherium* holotypes and lectotypes, even allowing for allometric distortion. *Zygomaturus macleayi* cannot be placed in any existing diprotodontid genus although it does share many features in common with the Pliocene *Euryzygoma*. It is therefore placed in a new monotypic genus.

Zygomaturus creedii was described by Krefft (1873) on the basis of a fractured right premaxilla with I^1 and other incisor fragments. Only the incisor remains in the Australian Museum. The holotype is indistinguishable from other I^1s from *Zygomaturus trilobus* and therefore *Z. creedii* is regarded as its junior synonym.

Studies of the Late Cainozoic diprotodontid marsupials of Australia 3. Key to the identification of lower molars

MACKNESS, B. 1994
School of Biological Sciences, University of New South Wales, Kensington, New South Wales, 2033.

The fossil remains of diprotodontids are commonly found as isolated molars or as dentary and/or

maxillary fragments. A lack of recognisable genera-specific features has resulted in confusing taxonomic assignments. Examination of an extensive collection of late Cainozoic dentary fragments from Australia has revealed a number of features useful for distinguishing genera. The poster presents a key to the identification of the lower molars of *Diprotodon, Euowenia, Euryzygoma, Nototherium* and *Zygomaturus*. This, along with a guide to the lower premolars presently in preparation by Mackness should provide the basis for more consistent determination of diprotodontid species diversity and distribution in the late Cainozoic of Australia.

An enigmatic family of marsupials from the Early Pliocene Bluff Downs Local Fauna of northeastern Queensland

MACKNESS, B., ARCHER, M. & MUIRHEAD, J. 1994
School of Biological Sciences, University of New South Wales, Kensington, New South Wales, 2033.

Discovery of a right mandible from the early Pliocene Bluff Downs Local Fauna of the Allingham Formation, northeastern Queensland, provides evidence for a highly specialised group of marsupials that has no previously known representatives. Key features are tribosphenid-like molars with elaborate buccal and anterior cingula, unique buccal cusps, complex cusp and crest relationships in a gradient that increases from M_5 to M_2, complex P_3 morphology including an elaborate postenior cusp and a prominently bicuspid P_2. The M_5 and M_4 have some features reminiscent of peramelemorphians but none of these are undoubted synapomorphies. The M_2 and premolars exhibit other features that are diprotodontian-like although these may be convergent. Some aspects of lower morphology most closely resemble those seen in late Cretaceous glasbiids from North America and early Tertiary didelphimorphs (possibly glasbiids) from South America. These resemblances too are most likely to be convergent. Precise occlusal and possibly thegotic wear on all blades indicates that this extraordinary morphology is matched by precise occlusal counterparts in the as yet unknown upper dentition rather than abnormal and that this individual lived for a long time. Because there are no undoubted synapomorphies shared with any previously known family, we propose a new monotypic family for this taxon. Its highly distinctive morphology suggests antiquity that well predates the early Pliocene and demonstrates that not all contemporary lineages of middle Tertiary marsupials were sampled by the otherwise diverse Oligo-Miocene communities of South Australia and Queensland.

The Spring Park Local Fauna, a new Late Tertiary fossil assemblage from northern Australia

MACKNESS[1], B., MCNAMARA[2], G., MICHNA[3], P., COLEMAN[3], S. & GODTHELP[1], H. 1994
1. School of Biological Sciences, University of New South Wales, Kensington, New South Wales, 2033.
2. Department of Geology, James Cook University, Townsville, Queensland, 4811.
3. Townsville Grammar School, Townsville, Queensland, 4811.

Preliminary investigation of a series of complex freshwater, fluviatile quartz sand and clay deposits from Blaggard Creek, northwest of Charters Towers, northeastern Queensland has revealed a rich collection of fossils. The fauna, here named the Spring Park Local Fauna, contains: *Zygomaturus* sp. cf. *Z. trilobus* , a new species of *Euowenia, Palorchestes parvus*, another palorchestid, a phascolarctid, several macropodids, *Pallimnarchus* sp. cf. *P. pollens*, a new crocodilian and a python as well as remains of turtles and fish. The deposit is subjacent to Pliocene basalts. Sediment grain size and sedimentary structures mitigate against the idea that the deposit may have resulted from accumulation at the edge of a basalt bluff and suggests a stream too large to have been in this position after basalt deposition. Therefore, the deposit is nominally assessed as being of Pliocene age based on its geomorphology and biocorrelation with Chinchilla and Bluff Downs faunas.

Three-dimensional analysis of variation in marsupial teeth using computed tomographic scans

MACKNESS[1], B. & SELDON[2], L. 1994
1. School of Biological Sciences, University of New South Wales, Kensington, New South Wales, 2033.
2. Department of Otolaryngology, University of Melbourne, Parkville, Victoria, 3052.

The analysis of variation in the diagnostic P^3 of *Zygomaturus trilobus* has been undertaken by means of computed tomography. The study was carried out in conjunction with the Cochlear Implant Program of the Department of Otolaryngology, University of Melbourne, which uses computed tomographic scans for reconstructing intricate anatomical features such as the temporal bone to assist surgeons. The input data was obtained via a series of CT scans taken at 1.00 mm intervals, from the alveolus to the tooth crown, on a suite of isolated P^3 teeth suspended in a polystyrene foam collar. The scans, on film, were then digitised from a light box using a Panasonic WV-BL200 video camera connected to a IBM AT compatible personal computer and stored in a CompuServe GIF graphics interchange format. A Data Translation DT2851 medium resolution video card with 512 x 512 pixels and 256 colours was the only 'special' piece of hardware used in the study. An automatic edge detection system was used to combine the scanned images to form a 3D computer model. Automatic analysis of a number of variables was then possible. This included plotting the ratio of the length and width along the entire midline of the tooth at 1.00 mm intervals. Individual teeth were also divided into four quadrants and analysed for shape using the formula ($10–40\pi A / P^2$) as well as for volume and surface area. The study highlights the effectiveness of computers in assessing previously subjective characters such as 'shape', surface area and quadrant volumes as well as providing a suitable technique for close examination of variation in a number of isolated individuals.

The morphology and relationships of thelodonts, Siluro-Devonian agnathans

MARSS[1], T. & RITCHIE[2], A. 1994
1. Institute of Geology, Tallinn, Estonia
2. Australian Museum, Sydney, New South Wales, 2000.

Thelodonts are a group of poorly-known Siluro-Devonian agnathans characterised by a micromeric dermal skeleton consisting entirely of small scales. Complete thelodonts are very rare but articulated specimens are known from sites in Scotland, England, Estonia, Norway and Canada. Isolated scales, by contrast, are often locally abundant, widely distributed in Siluro-Devonian sediments and are being increasingly used in biostratigraphic studies world-wide, including Australia and Antarctica. Recent discoveries of articulated thelodonts provide new information on the variation in shape of thelodont scales in different parts of the dermal skeleton, the position of the eyes, the nature of the mouth and the branchial apparatus, the size and the shape of the lateral, dorsal, ventral and caudal fins. The relationships of thelodonts with other Palaeozoic agnathans will be discussed.

The Late Miocene Ongeva Local Fauna from the Waite Formation of central Australia

MEGIRIAN[1], D., MURRAY[1], P. F. & WELLS[2], R. T. 1994
1. Northern Territory Museum, Darwin, Northern Territory, 0800.
2. Flinders University of South Australia, Bedford Park, South Australia, 5042.

The Ongeva Local Fauna (LF) from the Waite Formation of central Australia is biochronologically significant because it is in lithostratigraphic superposition to, and unconformably separated from, the Alcoota LF. It contains a zygomaturine diprotodontid (description in press) that is structurally intermediate between *Kolopsis torus* Woodburne from the Alcoota Local Fauna, and *Zygomaturus gilli* Stirton from the Beaumaris LF of Victoria. *Kolopsis torus* is also present in the Ongeva LF, though the Ongeva LF specimens differ slightly in some measurements from the Alcoota population. A morphospecies distinction of the two populations is not justified on the available evidence. The indications are that a cladogenetic event occurred in the Zygomaturinae between Alcoota and Ongeva LF times, an interpretation consistent with the presence of a *Zygomaturus* sp. and a *Kolopsis* sp. in the younger Beaumaris LF. Dromornithidae are also common elements in the Ongeva LF, but have not yet been analysed in detail. The indications are that a *Dromornis* sp. cf. *D. stirtoni* and an *Ilbandornis* sp. are present. A crocodilian, *Quinkana* sp., is represented by a dentary and a relatively large number of ziphodont teeth. The most remarkable fossils, however, are large, loosely-deposited coprolites draped over the bones. Two quarries are now producing Ongeva LF material, but their yields may eventually be limited by the huge overburdens that accompany excavating into the sides of steep hills.

Late Cainozoic crocodilians collected by the 1980 and 1983 FUAM Expeditions into the Lake Eyre Basin of South Australia

MEGIRIAN[1], D., WELLS[2], R. T. & TEDFORD[3], R. H. 1994
1. Northern Territory Museum, Darwin, Northern Territory, 0800.
2. Flinders University of South Australia, Bedford Park, South Australia, 5042.
3. Department of Vertebrate Paleontology, American Museum of Natural History, New York, N. Y., 10024, United States of America.

The Flinders University-American Museum of Natural History (FUAM) collection of crocodilian material from Pliocene and Pleistocene strata of the Lake Eyre Basin is just one of several collections made since 1892. Virtually none of the material of this geological age and provenance has been described, but has been variously assigned to the extinct form *Pallimnarchus pollens* de Vis, or to the extant species *Crocodylus porosus* Schneider. The distinction of fragmentary remains of these two taxa has proved difficult in the past. Poor stratigraphic control has also hampered the interpretation of crocodilian succession. The stratigraphy of the Lake Eyre Basin Pliocene and Pleistocene has now been resolved in some detail, and the stratigraphic provenance of the FUAM material is recorded. There is *prima facie* evidence in the FUAM collection, from specimens that could not have been re-worked, for the presence of a *Pallimnarchus*-like form in the mid Pliocene (estimated age: 3.9–3.4 Ma) Tirari Formation and the late Pleistocene (estimated age, 0.2 Ma) Kutjitara Formation. There is no evidence in the FUAM collection for the presence of a *Crocodylus*-like form in the Tirari Formation. One *Crocodylus*-like specimen from the Kutjitara Formation differs in preservation from other material of that provenance and is possibly reworked. Only two potentially diagnostic specimens were collected from the latest Pleistocene (estimated age: 0.04 Ma) Katipiri Formation: a jugal that may be referable to *Crocodylus*, and a maxillary fragment most closely resembling *Australosuchus clarkei* Willis and Molnar from the mid-Tertiary Etadunna Formation which forms the basement to the Pliocene and Pleistocene strata.

Post-cranial descriptions of *Ilaria* and *Ngapakaldia* (Vombatiformes, Marsupiala) and the phylogeny of the vombatiforms based on post-cranial morphology

MUNSON, C. 1994
Moreno Valley, CA 92553, United States of America.

The post-crania of the vombatiform marsupial *Ilaria illumidens* from medial Miocene strata of South Australia are described and compared to those of other vombatiforms, with the observation that *Ilaria* shares a similar morphology of the manus and pes with living wombats. While this indicates a certain degree of fossorial activity, the size and vertebral morphology of *Ilaria* argue against a burrowing lifestyle. Another medial Miocene vombatiform, *Ngapakaldia tedfordi*, is described as having a plesiomorphic vombatiform skeleton similar in many ways to that of the phalangeriform possums, but with adaptations for greater size and a plantigrade, terrestrial habitus. Besides stouter and more robust limbs, these adaptations are evident in the concave dorsal surface and laterally facing fibular facet of the astragalus that creates a less flexible upper ankle joint.

For this study, a cladistic analysis was made using the post-crania of all the families in the Vombatiformes and several species representing outgroups, in order to establish synapomorphies uniting the group and to evaluate the position of these two genera within it. The results indicate that the ilariids and vombatids probably share a common ancestor, based on the similarity of the metapodials and phalanges, especially the uniquely identical morphology of the proximal metapodial facets. *Ngapakaldia*'s similarity in form to phalangeriform possums reflects the arboreal ancestry of the vombatiform clade and indicates the plesiomorphic state from which the post-crania of other, more specialised vombatiform families (i.e. fossorial wombats and ilariids) are derived.

Recent *Diprotodon* discoveries in South Australia

PLEDGE, N. S. 1994
South Australian Museum, Adelaide, South Australia, 5000.

From the early days of the colony, *Diprotodon* remains have been found. Prior to the Lake Callabonna discoveries, the best were a skull from near Gawler in 1891 (now apparently lost) and a skull from Baldina Creek near Burra in 1890. Since 1970, and the publicity engendered by the expedition to Lake Callabonna in that year, four chance discoveries have been made in the Adelaide area, and two on the West Coast. More material has been obtained from a Port Pirie site, and minor records made for the Woomera area, Morgan and Naracoorte.

A badly tumbled and rolled molar found in beach gravels at Hallett Cove in 1970 may now be related to a partial pelvis and other bones and teeth found in 1992 in the banks of the Field River which flows into the southern end of the cove. Soil samples from this site have been taken for thermoluminescent dating by Prof. J. Prescott, University of Adelaide. A similar discovery was made in early 1993 in the Little Para River, near Salisbury. In 1980, a jaw fragment was found in a sewer trench near Darley Road, Paradise, on the River Torrens. *Diprotodon* jaws and other bones have been found in lithified Bridgewater Formation (coastal dune sand) at Sheringa Beach, west of Port Lincoln, and also near Head of the Bight, west of Ceduna. These bones are well preserved but firmly embedded in the rock. Jaws and a partial skeleton have been recovered from an old locality – a sand quarry near Port Pirie, but have been damaged by the bulldozers. A poorly preserved skeleton is known in Elizabeth Creek which flows into Pernatty Lagoon near Woomera.

Mineralised tooth fragments have been collected from river alluvium excavated from a farm dam near Morgan, on the River Murray, and several teeth were found during excavations in Henschke Fossil Cave at Naracoorte. Bones embedded in reef rock at a depth of five metres off Victor Harbor have been reported but not yet confirmed.

A new extinct sthenurine kangaroo (Marsupiala, Macropodidae) from southeastern Australia

PRIDEAUX, G. J. & WELLS, R. T. 1994
School of Biological Sciences, Flinders University of South Australia, Bedford Park, South Australia, 5042.

A new species of *Simosthenurus* is described from Late Pleistocene deposits in southeastern South Australia, western Victoria, northern and southeastern New South Wales, northwestern Tasmania and the Nullarbor Plain, Western Australia. The species is similar in size and mandibular morphology to *Simo. brownei*, but its cranium is more dolichocephalic with a less inflated nasal region. The dentition is distinctive and, although similar in size to *Simo. occidentalis*, several molar characters appear closer to *Sthenurus andersoni* in morphology. Because the new species exhibits features previously only considered typical of either *Simosthenurus* or *Sthenurus*, a thorough reassessment of sthenurine generic relations is impelled. Whether or not the distribution of craniodental character states within the groups confirms the tentative placement of this new form within *Simosthenurus*, it probably evolved soon after split of the *Simosthenurus* and *Sthenurus* lineages.

An ornithomimosaur and protoceratopsian from the early Cretaceous of southeastern Australia

RICH[1], T. H. & VICKERS-RICH[2], P. 1994
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2. Department of Earth Sciences, Monash University, Clayton, Victoria, 3168.

Ornithomimosaurs were intermediate-sized, agile, edentulous theropod dinosaurs best known from the late Cretaceous of the Northern Hemisphere. Fragmentary records of them exist there in the early Cretaceous and possibly the late Jurassic. *Elaphrosaurus bambergi* from the late Jurassic Tendaguru of Tanzania is likely to be a primitive member of this group of dinosaurs.

A pair of femora, one of an adult and one of a juvenile about 45% as large as the former were found at the late Aptian – early Albian Dinosaur Cove site, Victoria, Australia, in 1991. The relatively large size of the lateral distal condyle in comparison to the medial distal condyle characterises these specimens and the ornithomimosaurs among theropods (Barsbold & Osmolska 1990). The lesser trochanter is plesiomorphic-primitive in being less expanded than is typical of the well known late Cretaceous ornithomimosaurs.

Ceratopsians are common late Cretaceous dinosaurs of North America and Asia with questionable records from Europe and South America. None have previously been reported from the early Cretaceous. An ulna recovered from early Aptian sediments of the Strzelecki Group at the Arch near Kilcunda, Victoria, Australia, shares the foreshortened and mediolaterally compressed form characteristic of ceratopsians and not known in other vertebrate groups. In particular, the Australian specimen is remarkably similar in both size and morphology to an ulna of *Leptoceratops gracilis* from the Maastrichtian of Alberta, Canada.

The presence in the early Cretaceous of Australia of two dinosaur groups best known from the late Cretaceous of the Northern Hemisphere suggests that an hypothesis of either's origin on the Gondwana continents should not be rejected out of hand.

BARSBOLD, R. & OSMOLSKA, H., 1990. Ornithomimosauria. Pp. 225–248 in 'The Dinosauria' Ed. D. B. Weishampel, P. Dodson & H. Osmolska. University of California Press: Berkeley.

The molar / premolar boundary in the macropodiforms: cracking the code of molar cusp patterns in the transitional zone

RIDE, W. D. L. 1994
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The striking functional discontinuity at the molar/premolar boundary of many macropodiforms (kangaroos, wallabies and rat-kangaroos) is reflected in cusp pattern modification in the deciduous premolar and the first molar. Following recent analysis of this in *Jackmahoneya*, other propleopinines, and *Hypsiprymnodon*, the analysis is extended to the Macropodidae.

The great Canowindra Devonian fish kill

RITCHIE, A. 1994
Australian Museum, Sydney, New South Wales, 2000.

The richest fossil fish site in Australia, evidence of a unique Late Devonian mass fish-kill, was first discovered in 1956 near Canowindra, N. S. W. Using a 22 tonne excavator, Alex Ritchie relocated the fish horizon in January 1993. Preliminary excavations indicate that the site contains hundreds, probably thousands, of complete fish specimens. Five taxa have been recognised to date. Three types of armoured fishes, placoderms, are present. Antiarchs (*Bothriolepis* and *Remigolepis*) are dominant, forming about 95% of the fauna. An arthrodire (*Groenlandaspis*) is present but is extremely rare. The fourth type present is a crossopterygian, an elongate, air-breathing, lobe-finned fish named *Canowindra* after the town near where it was discovered. The January '93 excavation turned up four new crossopterygian specimens of a new form, different from *Canowindra*. Two of these were giants, over 1.5 m long.

Alex Ritchie hopes to carry out a major excavation at Canowindra in June, using logistic support provided by the local shire council and enlisting local high school students as volunteers. The enormous scale and importance of this fossil site is now clear – there could be several hundred tonnes of rich fish-bearing slabs awaiting recovery, easily excavated and readily accessible in a roadside locality! The great Canowindra Devonian fish-kill provides a unique opportunity for a detailed population study on an entire fauna, killed suddenly and buried quickly. Given sufficient community support and funding Canowindra has enormous potential for a major tourist, educational and scientific attraction for central west New South Wales.

Burnt ratite eggshell from Pleistocene aeolian sediments

SMITH[1], M. A., MILLER[2], G. & VAN TETS[1,3], G. F. 1994
1. Department of Prehistory, Australian National University, Canberra, Australian Capital Territory, 2600.
2. Center for Geochronological Research, University of Colorado, Boulder, CO, 80309, United States of America.
3. CSIRO Division of Wildlife & Ecology, Lyneham, Australian Capital Territory, 2602.

The history of *Genyornis newtoni* (Dromornithidae: Aves) is complicated by uncertainty surrounding the date of extinction and role of human predation. Work in progress near Wood Point, on the eastern side of Spencer Gulf, S. A., has revealed a thin horizon of burnt *Genyornis* and *Dromaius* eggshell stratified within a Pleistocene dune core. Dates of 47± 5 ka have been obtained for the eggshell of both ratite species using the protein diagenesis (amino acid racemisation) method. These dates are amongst the most recent obtained for *Genyornis* in a large series of such determinations on eggshell across the southeastern sector of the arid and semi-arid zone and suggest that this species was extinct over a large part of its former range by ca. 40–50 ka. Work is in progress to verify the AAS results using other dating methods, including AMS C14 on the eggshell and TL on the dune sediments. Several features of the site suggest a human agency for the accumulation of the eggshell.

Lake Callabonna: 'Veritable necropolis of gigantic extinct marsupials and birds'

TEDFORD, R. H. 1994
Department of Vertebrate Paleontology, American Museum of Natural History, New York, N.Y., 10024, United States of America.

The famous fossiliferous deposit at Lake Callabonna, northern South Australia, lies at the base of the local Quaternary sequence in laminated clays and fine sands tentatively correlated with the Millyera Formation of nearby Lake Frome. At Lake Callabonna these deposits accumulated in a lake of variable salinity, several times the size of the present saltpan. Plant remains contained in the deposits indicate a

more arborescent flora than occurs near the lake today but one containing taxa still living in the region. This and stratigraphic evidence suggests a seasonal, yet wetter than present, climate with a fluctuating water-table. Geological correlations with Lake Frome suggest a medial Pleistocene age, 0.1–0.7 Ma, as the span during which the Callabonna fauna lived.

The large-bodied vertebrates were mired while walking across the lake floor when the surface appeared dry but the underlying clays were water saturated. This mode of accumulation has yielded articulated skeletons of taxa known elsewhere only from fragments. In addition to the well-known remains of *Diprotodon optatum* and possibly a second, smaller species, there are three species of *Sthenurus*: a new giant form, the somewhat smaller *S. tindalei*, and the considerably smaller *S. andersoni*. Other kangaroos include: *Macropus* sp. cf. *M. titan*, a smaller *Macropus* sp., and *Protemnodon* sp. cf. *P. brehus*. Skeletons of *Phascolonus gigas*, the dromornithid *Genyornis newtoni*, and an emu similar to the living species are also present.

The Lancefield megafauna site, Victoria

VAN HUET, S. 1994
Department of Earth Science, Monash University, Clayton, Victoria, 3168

The Lancefield Quaternary megafaunal site was the third megafaunal locality to be discovered in Australia. There are three separate sites located at Lancefield; the Classic, located in 1974, the South, located in 1983 and Maynes Site, first discovered in 1843 and subsequently relocated in 1990. The cause of the death of the megafauna at Lancefield is related to climatic changes occurring across Australia at the time of the collection. These changes had a detrimental effect on the habitats of browsing megafauna and their ecologically dependent carnivores and scavengers. Disease may have affected animals that were in a weakened state through lack of food and water.

The presence of large numbers of bones in a concentrated area is due to transportational processes. The topographical nature of the area and the characteristic Quaternary climate encouraged major seasonal rainfall and sheet flooding. Bias in the collection is also due to transportational processes. Abrasion during transportation led to the destruction of the more fragile elements and weathering would have added to the bones fragility and subsequent fragmentation. Other biases in the collection, such as up to 90% of the elements being identified as the species *Macropus titan*, and the absence of juveniles of this species may well be related to the climatic conditions and subsequent habitat changes in the area at the time.

Functional anatomy of the Lake Callabonna sthenurine kangaroos

WELLS[1], R. T. & TEDFORD[2], R. H. 1994
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2. Department of Vertebrate Paleontology, American Museum of Natural History, New York, N.Y., 10024, United States of America.

This paper reports on our functional anatomical study of three species of the extinct kangaroo *Sthenurus* from Lake Callabonna, northern South Australia. Complete skeletons of these animals were recovered from the lake sediments thereby providing an unparalledled opportunity for comparative anatomical study. The large taxa show sexual dimorphism. All differ from extant *Macropus* species in having short deep skull, long forefeet with reduced lateral digits, and functionally monodactyl hindfeet. The hand is modified for grasping, the forelimb may be raised above the head to reach high browse; the vertebral column shows limited flexion, but considerable extension in the anterior end; the pelvis is modified for flexion and adduction of the thigh; the hindlimb is more massive than *Macropus* species, and although of similar proportions there is greater emphasis on tendons and ligaments to augment muscular action. The mechanics of movement in these extinct species will be discussed.

PS07
S-726
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RECORDS OF THE SOUTH AUSTRALIAN MUSEUM

VOLUME 28
1995

Published by the South Australian Museum,
North Terrace, Adelaide, South Australia 5000.

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Volume 28(1) was published on 30 October 1995.
Volume 28(2) was published on 29 December 1995.

ISSN 0376–2750

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FOUR NEW SPECIES OF THE FAMILY OPHELIIDAE (POLYCHAETA) FROM SOUTHERN AUSTRALIA

G. HARTMANN-SCHRÖDER & S. A. PARKER*

HARTMANN-SCHRÖDER, G. & PARKER, S. A. 1995. Four new species of the family Opheliidae (Polychaeta) from southern Australia. *Records of the South Australian Museum* **28**(1): 1–12.

Recent examination of specimens of *Euzonus*, *Ophelia*, *Ophelina* and *Travisia* (Polychaeta: Opheliidae) in the South Australian Museum revealed a previously undescribed species in each genus: *Euzonus zeidleri* sp. nov., *Ophelia bulbibranchiata* sp. nov., *Ophelina longicirrata* sp. nov. and *Travisia oksae* sp. nov. The previous report of *Travisia forbesii* Johnston, 1840 from Victoria is referred to *T. oksae* sp. nov. *T. oksae* sp. nov. is known from South Australia and Victoria, the other three from South Australia only. *Euzonus zeidleri* sp. nov. represents the first record of its genus for Australia

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The family Opheliidae is widely distributed in the seas of all climatic zones from the polar regions to the tropics, and from shallow waters to abyssal depths. Most members of the family live as deposit-feeding burrowers in various types of sediment.

Six genera and 15 named species of opheliids have so far been reported from Australia (mainly from southern Australia and New South Wales): *Armandia* Filippi, 1861: *A. maculata* (Webster, 1884), *A. intermedia* Fauvel, 1902, *A. secundariopapillata* Hartmann-Schröder, 1984, *A. bilobata* Hartmann-Schröder, 1986; *Ophelia* Savigny, 1818: *O. ashworthi* Fauvel, 1917, *O. dannevigi* Benham, 1916, *O. elongata* Hutchings & Murray, 1984, *O. multibranchia* Hutchings & Murray, 1984, *Lobochesis* Hutchings & Murray, 1984: *L. bibrancha* Hutchings & Murray, 1984, *L. longiseta* Hutchings & Murray, 1984; *Ophelina* Örsted, 1843: *O. breviata* (Ehlers, 1913)[1], *O. gigantea* (Rullier, 1965); *Polyophthalmus* Quatrefages, 1850: *P. pictus* (Dujardin, 1839); *Travisia* Johnston, 1840: *T. lithophila* Kinberg, 1866, *T. olens* Ehlers, 1897 (Day & Hutchings 1979, Hutchings 1982, Hutchings & Murray 1984, Hartmann-Schröder 1980, 1984, 1985, 1986). A further species, *Travisia forbesii* Johnston, 1840, has been reported from Victoria (Poore *et. al.* 1975), but the specimens proved, upon examination, to have been misidentified (see below under *T. oksae* sp. nov.). A seventh genus, *Euzonus* Grube, 1866, has to date been reported in Australasia only from New Zealand (*E. otagoensis* Probert, 1976).

Materials and methods

The present study is based largely on material in the South Australian Museum, *viz.* specimens of *Ophelia* and *Ophelina* obtained at Pearson Island in June 1973, a large series of *Travisia* from upper Spencer Gulf collected by E. Oks of the South Australian Fisheries Department in 1985–1987, and a large series of *Euzonus* collected at Reevesby Island in the Sir Joseph Banks Group in 1985 and 1986 by the junior author. This new material was augmented by a loan of *Travisia* from the NMV. Comparative material of previously described species included the four (of six) syntypes of *Ophelia ashworthi* in the SAM, and from the ZMH the syntypes of *Euzonus furciferus* (Ehlers, 1897), and the specimens of *T. forbesii*. The subfamilial and generic classification follows Hartmann–Schröder (1971).

Measurements are in millimetres, made with an eyepiece graticule. Drawings were executed with the aid of a camera lucida on a Zeiss microscope. Abbreviations of institutions mentioned are: AM, Australian Museum, Sydney; BMNH, Natural History Museum, London; NMV, Museum of Victoria, Melbourne; NTM, Northern Territory Museum, Darwin; SAM, South Australian Museum, Adelaide; USNM, National Museum of Natural History, Washington DC; ZMH, Zoological Museum, Hamburg. Material is deposited in the AM, NTM, SAM, USNM and ZMH.

* Shane Parker died on 21 November 1992.

[1] Listed as *Ophelia breviata* by Day & Hutchings (1979:129)

Systematics

Family OPHELIIDAE Malmgren,1867
Subfamily OPHELIINAE Malmgren, 1867

Genus *Euzonus* Grube, 1866

Euzonus zeidleri sp. nov.
(Figs 1–5)

Types (all collected on Reevesby Island, South Australia, by S. A. Parker, measurements for paratypes are of length of longest specimen in each sample).

Holotype: Haystack Bay, 20.i.1986, SAM E2145; length 28 mm, width (at thorax) 3.5 mm.

Paratypes (276 specimens): Haystack Bay, 21.i.1985, SAM 2146(36), 23 mm; Haystack Bay, 31.i.1985, SAM E2147(58), 22 mm; McCoy Bay, 22.i.1985, SAM E2148(36), 31 mm; McCoy Bay, 31.i.1985, SAM E2149(2), 19 mm; Haystack Bay, 20.i.1986, SAM E2150(73)/ZMH: P20816(6)/ USNM 169135 (4)/AM W21745 (4)/ NTM W6421–424(4), 27 mm, Haystack Bay, 22.i.1986, SAM E2151(14), 35 mm, Haystack Bay, 30.i.1986, SAM E2152(9), 28 mm; Haystack Bay, 1.ii.1985, SAM E2153(26), 24 mm.

Other material examined

Euzonus furciferus (Ehlers, 1897): syntypes, Punta Arenas, Strait of Magellan, ZMH: V4869(7); Itanhan, Brazil, ZMH: P15144(1); Santos, Brazil, ZMH: P15421(4); Zapallar, Chile, ZMH: P15124(1).

Diagnosis

A *Euzonus* with bifurcate branchiae (character of subgenus *Thoracophelia* Ehlers, 1897 *sensu* Hartman 1956), with body formula 12a + 20b + 6a (*i.e.* branchiae occuring on setigers 13–32); all branchiae bifurcate; branches of branchiae subequal, superior one bearing 1–2 small pinnae; setae on segments 1–36; pygidium relatively large, broad, lacking elongated terminal (ventral) cirrus, 6–9 lateral cirri on each side.

Description

Body fusiform, 38 segments, 36 setigers, total length 9–35 mm; divided into three distinct regions: cephalic (prostomium and two setigers), thoracic (eight setigers) and abdominal (26 setigers and two asetigerous segments). All segments annulated. Prostomium with small apical point; eyes absent; nuchal pits present (Fig. 1). Thoracic region inflated, delimited from cephalic region by pronounced constriction, delimited from abdomen by thick, smooth lateral glandular ridges. Abdominal region comprising two prebranchial, 20 branchiate and six postbranchial segments (body formula thus 12a + 20b + 6a, see Tebble 1952). Last two asetigerous abdominal segments with close-set longitudinal furrows. Pygidium wide at base, broadly rounded at tip, not tapering to an elongated ventral cirrus; dorsal anal cirri disposed in a V over pygidium, 6–9 on each side (Fig. 5). Abdominal region bearing deep longitudinal midventral and lateral grooves, former continuing to pygidium, latter becoming shallower beyond last branchiate setiger (32nd).

Branchiae on setigers 13–32, bifurcate, branches subequal, superior branch bearing 1–2 small pinnae distally on dorsal surface (Fig. 2–4).

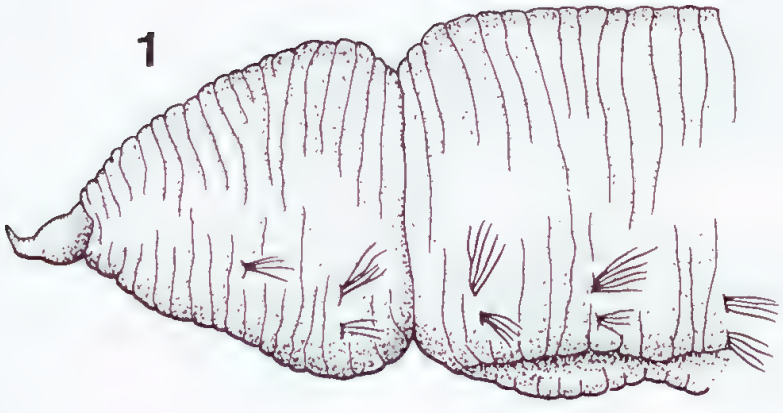
Parapodia barely or not visible, lobes immersed in surrounding tissue, from which bundles of setae appear to arise directly. Notosetae and neurosetae simple, capillary, 6–25 and 6–30 setae per bundle respectively, on segments 1–36. Neurosetae shorter than notosetae of same setiger, except on setigers 34–36, where they increase to a subequal length; also, setae of setdgers 34–36 markedly longer than those of preceding setigers, tending to curve and spread conspicuously (Fig.5).

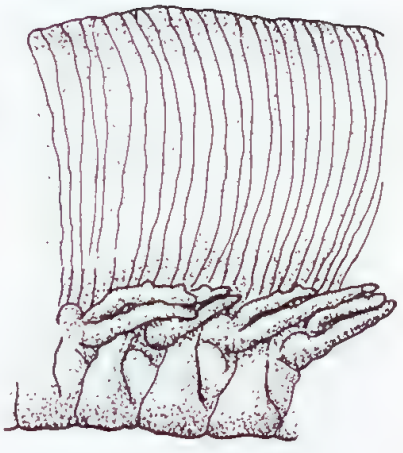
Colour of individuals in life bright red, especially at anterior end.

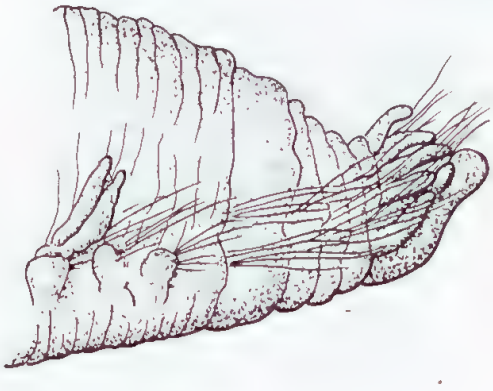
Comparisons with other species

Eleven species have been described to date (Rozbaczylo & Zamorano 1970, Probert 1976). Of these, six fall in the subgenus *Thoracophelia* Ehlers, 1897, *sensu* Hartman 1956, having the branchiae bifurcate rather than trifurcate or pectinate: *E. furciferus* (Ehlers, 1897, type species of *Thoracophelia*), *E. mucronata* (Treadwell, 1914), *E. williamsi* (Hartman, 1938), *E. profundus* Hartman, 1967, *E. otagoensis* Probert, 1976 and *E. heterocirrus* Rozbaczylo & Zamorano, 1970.

Within this group, *E. zeidleri* sp. nov. is most similar to *E. furciferus* of South America, the only member of the subgenus with a body formula of 12a + 20b + 6a, *i.e.* twelve abranchiate anterior segments, 20 branchiate segments and 6 posterior abranchiate segments. The closest species geographically, *E. otagoensis* of New Zealand, differs in having a body formula of 14a + 18b + 6a. From *E. furciferus*, *E. zeidleri* differs in possessing 1–2 small pinnae on the superior branch of the branchiae (absent in *E. furciferus*),







FIGURES 1–5. *Euzonus zeidleri* sp. nov. **1**, anterior end, lateral view; **2**, segments from middle of body, lateral view (setae omitted); **3**, median body region showing branchiae; **4**, branchiae, detail; **5**, posterior end, lateral view (all of paratype ZMH: P–20816).

the last two segments asetigerous (last one asetigerous in *E. furciferus*), last 3–4 segments not telescoped together as in *E. furciferus*, pygidium relatively large, broad, bluntly rounded at tip, not small and tapering to elongated ventral cirrus as in *E. furciferus*, and 6–9 dorsal cirri on each side *vs* 4 on each side in *E. furciferus*.

Etymology

We name this species in honour of our colleague Wolfgang Zeidler, South Australian Museum, who led the 1985 and 1986 collecting trips to the Sir Joseph Banks Group.

Distribution and ecology

Euzonus zeidleri is known only from Haystack Bay and McCoy Bay, two quartz-grain surf-beaches on the eastern, weather side of Reevesby Island, Sir Joseph Banks Group, South Australia, where it was collected in damp sand of the lower and middle intertidal, within a spade's depth of the surface. Both beaches squeaked underfoot, and thus belong to the type known as singing beaches (for a discussion of this phenomenon, apparently produced by the shearing of the well-sorted, well rounded quartzgrains under pressure, see the account of Squeaky Beach, Victoria by Beasely 1972).

Subsequent to the discovery of *E. zeidleri*, S.A P. sought the species in other exposed sandy beaches, *e.g.* on Younghusband Peninsula and at Cape Jaffa, Boatswain's Point and Robe, south-eastern South Australia. None of these contained *E. zeidleri*, and none squeaked underfoot; all were of silicate rather than quartzgrains. In answer to our enquiry, Dr P. K. Probert (*in litt.* 11.iii.1992) confirmed our suspicion that the type locality of *Euzonus otagoensis* Probert, 1976 (Allan's Beach, Otago Peninsula, New Zealand) was a singing beach. It thus seems possible that the occurence of *E. zeidleri* and *E. otagoensis* (and perhaps other species of the genus) coincides with that of singing beaches, with their characteristic well-sorted, well-worn quartzgrains.

E. zeidleri was more abundant at Haystack Bay than at McCoy Bay; at the latter locality the quartzgrains averaged larger but were equally rounded. The only other macroscopic species observed in these beaches were the cosmopolitan marine acanthodriline oligochaete *Pontodrilus litoralis* (Grube, 1855; first South Australian record) and a minute enchytraeid oligochaete; these were collected at Haystack Bay, from less damp sand of the upper subtidal.

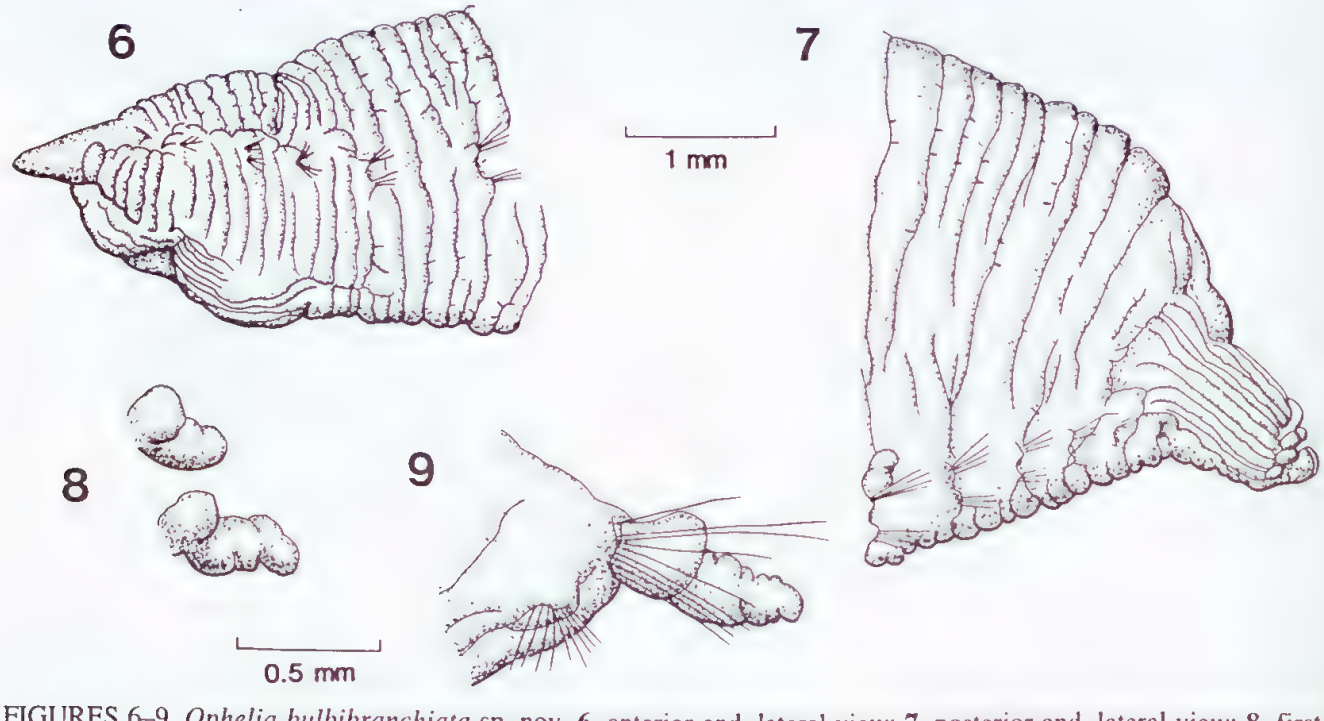
Genus *Ophelia* Savigny, 1818

Ophelia bulbibranchiata sp. nov.
(Figs 6–9)

Types

Holotype: Pearson Island, Investigator Group, South Australia, 26.vi.1973 (?coll.), SAM E1604, 30 setigers, length 30 mm, width 4 mm.

Paratypes: Same data as holotype: SAM



FIGURES 6–9. *Ophelia bulbibranchiata* sp. nov. **6**, anterior end, lateral view; **7**, posterior end, lateral view; **8**, first branchia from anterior segment; **9**, parapodium from middle of body.

E1605(3), 30 setigers, length 2–27 mm; ZMH: P20667(1), 30 setigers, length 30 mm.

Other material examined

Ophelia ashworthi Fauvel, 1917; 'St Vincent and Spencer Gulfs', South Australia, SAM E306 (four syntypes).

Diagnosis

An *Ophelia* 24–33 mm long with 30 setigers (including 10 prebranchial and 5 postbranchial), 15 pairs of simple, bulbous-based branchiae, 7–9 small and two large anal papillae; posterior dorsolateral ridges absent.

Description

Body club shaped, divided into anterior region of nine setigers and a posterior region of 21 setigers; a faint constriction between setigers 2 and 3. Prostomium small, conical, with small nuchal organs basally. No eyes visible. All segments annulate, those of anterior region somewhat areolate (Fig. 6); last five to six segments decreasing in size. Lateral furrows and a ventral furrow from setiger 11. Posterior segments lack dorsolateral ridges. Branchial fenestrations absent. Pygidium cylindrical with longitudinal folds or furrows, bearing seven to nine small dorsal and lateral anal papillae and two large ventral papillae (Fig. 7). First bundle of setae very small, easily overlooked, in region of mouth (Fig. 6). Subsequent parapodia with short, broadly rounded, postsetal lobes (Fig. 9). Setae capillary, notapodial slightly longer than neuropodial but nowhere obviously long. Fifteen pairs of branchiae from setiger 11 to setiger 25. Branchiae short, with bulbous bases, latter largest in middle branchiae (Fig.8–9). Nephridial pores not visible.

Comparisons with other species

O. bulbibranchiata sp. nov. is unique among the known species of the genus in possessing bulbous bases to the branchiae.

Species of *Ophelia* with a similar number of setigers to *O. bulbibranchiata* (30) are *O. multibranchia* Hutchings & Murray, 1984 (27), *O. peresi* Bellan & Picard, 1965 (29), *O. celtica* Amoureux & Dauvin, 1981 (29), *O. elongata* Hutchings & Murray, 1984 (30), *O. bipartita* Monro, 1936 (31), *O. dannevigi* Benham, 1916 (32) and *O. ashworthi* Fauvel, 1917 (32). Of these, *O. peresi*, *O. celtica* and *O. bipartita* have not been recorded in Australia. For differences see Table 1.

Etymology

The epithet *bulbibranchiata* (L.), refers to the bulbous shape of the basal part of the branchiae, unique in the genus.

TABLE 1. Comparison of *Ophelia bulbibranchiata* sp. nov. with other species of the genus with similar number of setigers

	Number of setigers	size in mm	number of prebranchial segments	number of postbranchial segments	pairs of branchiae	shape of branchiae	anal papillae	posterior dorsolateral ridges
O. multibranchiata	27	4-6	7	3	17	simple	10 small ones	absent?
O. peresi [1]	29	1–12	10	4	15	simple	12 small ones	absent
O. celtica [1]	29	30-45	10	3	16	simple	12 small + 2 large ones	absent
O. elongata	30	4-7	8	6	16	simple	10 small ones	present
O. bipartita [1]	31	63	9	5	17	simple	16 small + 2 large ones	present
O. dannevigi	32	20	10	3	19	simple	16 small + 2 large ones	absent?
O. ashworthi	32	?	10	2	20	bifurcate	several small + 1 large one	absent?
O. bulbibranchiata	30	24-33	10	5	15	bulbous base	7-9 small + 2 large ones	present

[1] no records from Australia

Distribution and ecology

Known only from the type series obtained at Pearson Island, eastern Great Australian Bight in 1973. No notes on depth or habitat accompany the specimens.

Subfamily OPHELININAE Hartmann-Schröder, 1971

Genus *Ophelina* Örsted, 1843

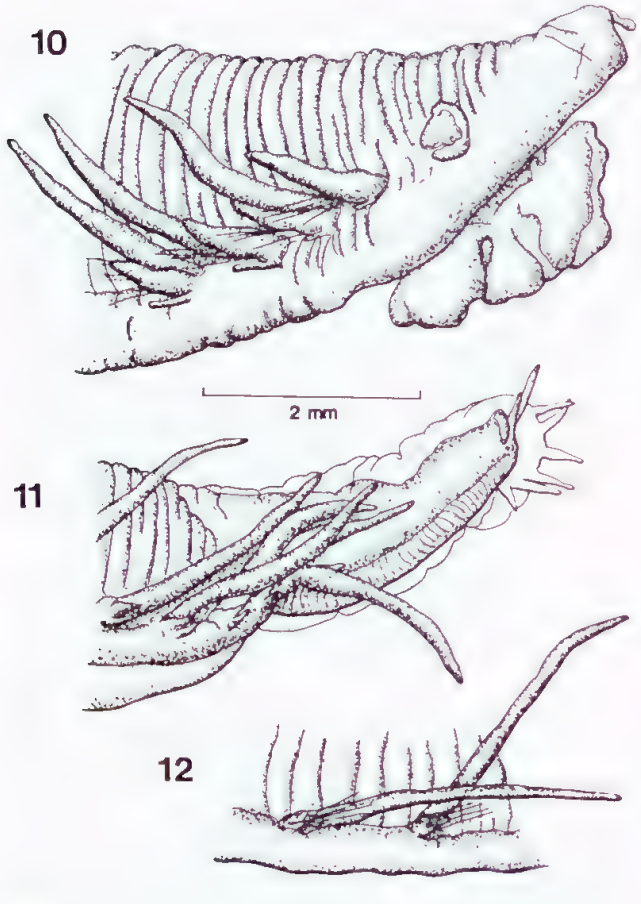
Ophelina longicirrata sp. nov.
(Figs 10–12)

Types

Holotype: Pearson Island, Investigator Group, South Australia, 26. vi. 1973 (?coll), SAM E1606, 41 setigers, length 52 mm, width 3.0 mm.

Other material examined

Ophelina breviata (Ehlers, 1913): holotype, ZMH: V8583, Kaiser-Wilhelm-II-Land, Antarctica, P190559(10), P19728(3), Antarctica; ZMH V9548(2), Bass Strait, ZMH: V11871(1), Port Lockray, New South Wales (Augener 1927: 215, at 37°05'S, 150°05'E).



FIGURES 10–12. *Ophelina longicirrata* sp. nov. **10**, anterior end, lateral view; **11**, posterior end, lateral view (cuticulum lifted away from underlying tissue through fixation); **12**, parapodia and branchiae of segments 34 and 35.

Diagnosis

A large *Ophelina* (52 mm long), with 41 setigers, long cirriform presetal lobes on anterior parapodia, long ventral cirri, anal tube cylindrical.

Description

Body fusiform, 41 setigers. Prostomium conical, longer than wide at base, with oblong palpode (Fig. 10). Proboscis a folded bag. No eyes visible. Nuchal organs slightly protruded, nuchal slits probably horseshoe-shaped. Segments strongly annulate. Anal tube cylindrical, annullate, only half width of last segments and as long as 5–6 last segments together. Anal opening ventroterminal, with 11 lanceolate anal papillae and a ventral cushion that may be base of a lost unpaired cirrus (Fig. 11). Presetal lobes of anterior parapodia long, cirriform, half as long as the branchiae on setiger 2, decreasing in size to setiger 12. From setiger 26, presetal lobes rounded-conical, with digitate extension of same length as ventral cirrus (Fig. 10–11). Ventral cirrus of setiger 1 small, filiform, increasing in size to setiger 14, thence of same length as presetal lobe (Fig. 11–12). Setae nowhere obviously long. Branchiae long, cirriform to filiform, overlapping on dorsum, absent only from setiger 1.

Comparisons with other species

Species of *Ophelina* with a cylindrical anal tube and cirriform presetal lobes are *O. hachaensis* Augener, 1934 and *O. fauveli* (Caullery, 1945), neither of which has been reported from Australia. *O. longicirrata* sp. nov. is much larger than *O. hachaensis*, with fewer setigers (52 mm, 41 setigers, *vs* 9 mm, 48 setigers), longer ventral cirri[1], and anal tube equal to the last 5–6 segments (*vs* the last 3–4 in *O. hachaensis*). *O. fauveli* has only 31 setigers and a length of 20 mm. The anal tube of both species is much shorter than that of *O. longicirrata*.

Besides *O. longicirrata*, two other species of *Ophelina* have been reported from Australia, *O. breviata* (Ehlers, 1913) of Bass Strait, New South Wales and Antarctica and *O. gigantea* (Rullier, 1965) of Queensland. *O. breviata* differs from *O.*

[1] Augener (1934) misinterpreted the long presetal lobe of *O.hachaensis* as a ventral cirrus.

longicirrata by its smaller size (28 setigers, 29 mm length). In *O. breviata* the branchiae are absent from the first and the last four segments, the posterior four segments are very short, and the presetal lobes are rounded rather than filiform. *O. gigantea* differs from the new species (and from all the other species discussed) in having the anal tube not cylindrical but spoon-shaped, open ventrally for the whole of its length. It is also larger (62–64 mm), with more setigers (65–68).

Etymology

The epithet *longicirrata* (L.) refers to the long cirriform ventral cirri.

Distribution and ecology

Known only from the unique holotype obtained at Pearson Island, eastern Great Australian Bight in 1973. No notes on depth or habitat accompany the specimen.

Subfamily TRAVISIINAE Hartmann-Schröder, 1971

Genus *Travisia* Johnston, 1840

Travisia oksae sp. nov.
(Figs 13–19)

Travisia forbesi: Poore, Rainer, Spies & Ward (*non* Johnston), 1975: 29, 56 (Port Phillip Bay, Victoria); Day & Hutchings (*non* Johnston), 1979: 129 (*pars*, Victoria).

Types

Holotype: Station 2, 32°35'04"S, 137°46'08"E, upper Spencer Gulf, South Australia 6 m, medium sand, coll. E. Oks, S. Aust. Fisheries Dept. xi.1985, SAM E2701, 27 segments, 24 setigers, length 15 mm, width 5.5 mm (moderately contracted).

Paratypes: (52 specimens, all collected by E. Oks, upper Spencer Gulf, 1985–1987): Station 2, SAM E2702 (4, in same sample as holotype) (27, 25, 20.5), SAM E2703(2) (27, 24, 12), SAM E2704(1) (26, 24, 8), SAM E2705(1) (26, 26, 5); Station 3, SAM E2706(1) (26, 25, 5), SAM E2707(4) (26, 24, 7), SAM E2708(6) (23, 20, 3), SAM E2718(1) (27, 24, 11); Station 4, SAM E2709(1) (26, 24, 4); Station 5, SAM E2710(3) (25, 25, 4.5); Station 6, SAM E2711(2) (26, 25, 9.5), SAM E2712(7)/USNM 169136 (l)/AM W21746 (1)/(26, 24, 9.5); Station 7, SAM E2713(1) (27, 25, 24); Station 8, SAM E2714(2) (27, 24, 19), ZMH: P20668(1) (27, 25, 19); Station 9, SAM E2715(1) (26, 22, 4.9), SAM E2716(7)/NTM W6425(1) (27, 24, 16.5), SAM E2717(1) (26, 23, 6), ZMH: P20669(3) (27, 24, 155) (figures in parentheses after each sample refer to the number of segments, number of setigers and total length of the largest individual in the sample).

Other material examined

T. oksae sp. nov.: Victoria: Port Phillip Environmental and Benthic survey: Stn 974, 13.x.1971, NMV F60027(2), 60028(5), 60029(3) (Poore *et al.* 1975, under *T. forbesi*) Western Port Environmental Study: Stn 1704, NMV F60035(2), Stn 1722, NMV F60033(5), 60037(2), 60043(3), Stn 1723, NMV F60030(1), 60040(8), Stn 1724, NMV F60036(1), 60039(3), 60044(1), Stn 1727, NMV F60041(1), Stn 1731, NMV F60042(1), Stn 1733, NMV F60031(1), Stn 1735, NMV F60034(2), 60038(3) (ix. 1973, i. 1974).

T. olens Ehlers, 1897: syntypes, Punta Arenas, Chile, ZMH: V4865(7), 4866(4), 4807(20), 4868(1); Punta Arenas, ZMH: V11937(1), ZMH: PE1031(6); South Georgia, ZMH: V11877(1); Antarctica, ZMH: P19085(9); Exmouth Gulf, Western Australia, ZMH: P16892(1) (Hartmann-Schröder 1980: 74).

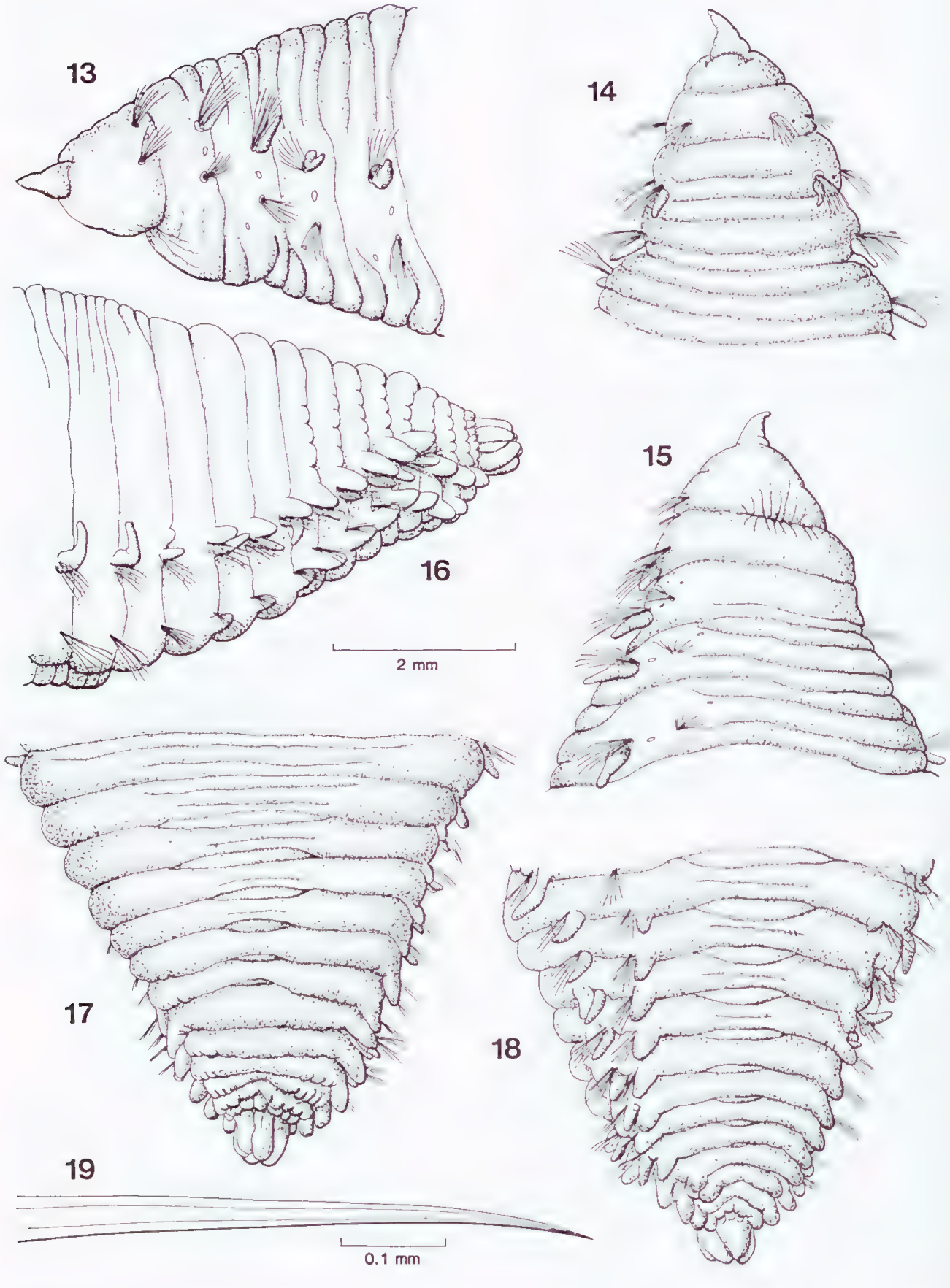
T. forbesi Johnston, 1840: North Sea, ZMH: V9190(5); Bay of Kiel, Baltic Sea, ZMH: P19241(22); Bohuslan, Sweden, ZMH: V5355(4); Tromso, Norway, ZMH: V7576(4), ZMH: PE1021(1); Spitzbergen, ZMH: PE1023(1); Jan Mayen, ZMH: V7527(1); Franz-Joseph-Land, ZMH: PE1025(4); Murman Coast, ZMH: V1439(2).

Diagnosis

A *Travisia* with 23–27 segments and 20–25 setigers, notopodial lobes from segment 15, neuropodial lobes from segment 16, and setae smooth, bilimbate.

Description

Body fusiform, 23–27 segments, 20–25 setigers, length 3–24 mm. Prostomium small conical, pointed, with small nuchal organs at base. First two segments faintly biannulate dorsally, lacking annulations ventrally. Segment 3 triannulate dorsally, biannulate ventrally (Figs 13–15). Segments 4–19 triannulate dorsally and ventrally, the annulations more and more restricted to the median part of dorsum and venter towards the posterior end of body (Figs 16–18). Segments 20–22 dorsally and segments 22–24 ventrally biannulate again; last five segments dorsally and last three segments ventrally lacking annulations.



FIGURES 13–19. *Travisia oksae* sp. nov. **13**, anterior end, lateral view; **14**, anterior end, dorsal view; **15**, anterior end, ventral view; **16**, posterior end, lateral view; **17**, posterior end, dorsal view; **18**, posterior end, ventral view; **19**, seta.

Posterior margin of the last nine segments with more or less obvious crenulations dorsally (Figs 16–17). Segment 27 very small and short. Anus terminal, encircled by seven blunt lobes (Figs 16-18). Entire surface of body (except the branchiae) covered with small pustules. Lateral parapodial region of body slightly swollen from segment 13 to end of body, expanding from parapodial region to near mid-dorsal and mid-ventral region in more posterior segments (Figs 16–18).

Fourteen anterior–most parapodia without lobes (Figs 13–15). Segment 15 with pair of minute notopodial lobes, above the bundle of notosetae; notopodial lobes increasing to ovoid lobes and still present on small last segment. Neuropodial lobes below neurosetae start on segment 16, similar in shape and size to notopodial lobes, but missing on segments 26 and 27 (Figs 16–18).

Bundles of notosetae and neurosetae from segment 1 to segment 24; last three segments usually asetigerous (though setae occur up to last segment in at least one specimen, in sample SAM E2710). Notosetae and neurosetae may be of different length within a bundle, otherwise similar, smooth and bilimbate (Fig. 19).

Branchiae simple, cirriform, present from segment 2 to 23 (Figs 13–15, 18). Lateral organ a small pit between bundles of notosetae and neurosetae. Nephridial pores present on segments 3–14, very conspicuous on segments 7–14 (Figs 13, 15).

Comparisons with other species

Species of *Travisia* with a similar number of setigers to *T. oksae* sp. nov. (22–29) are *T. forbesii* Johnston, 1840, *T. olens* Ehlers, 1897, *T. antarctica* Hartman, 1967, *T. brevis* Moore, 1906, *T. chiloensis* Kükenthal, 1887, *T. kerguelenensis* McIntosh, 1885 and *T. doellojuradoi* Rioja, 1944. Of these, only *T. olens* has been authentically reported from Australia (see above).

The species appearing most similar to *T. oksae* is the Arctic-boreal *T. forbesii* (23–26 segments, 22–25 setigers). It is identical to the former in the annulations of the segments, in the origins and shape of the notopodial and neuropodial lobes and the presence of nephridial pores on segment 3–14. It differs in being on average larger (11–32, *vs* 3–14 mm) and in having the setae minutely hirsute (*vs* smooth and bilimbate in *T. oksae*).

Also similar to *T. oksae* is *T. olens* from New Zealand, Western Australia and South Africa, which differs in being larger (up to 72 mm) with a greater average number of segments and setigers (27–32 segments, 23–29 setigers, *vs* 23–27 and 20–25), in having the neuropodial lobes present (though small) from segment 1, becoming larger from about segments 12–15 (*vs* present from segment 16 only in *T. oksae*), and in having the setae minutely hispid. The reports of *T. forbesii* from South Africa and New Zealand by Ehlers (1904, 1907, 1908) were referred to *T. olens* by Augener (1922). By their descriptions, Day's

TABLE 2. Details of stations at which *Travisia oksae* sp. nov. was collected.

Survey	Station	Lat.(S)	Long (E)	Depth(m)	Quartzgrain size
1	2	32°35'04"	137°46'08"	6	medium
	3	32°37'17"	137°46'00"	12	medium
	4	32°40'00"	137°45'28"	13	medium
	5	32°42'20"	137°47'26"	15	medium/coarse
	6	32°45'00"	137°50'00"	16	coarse
	7	32°47'18"	137°49'12"	15	coarse
	8	32°47'18"	137°50'00"	11	coarse
	9	32°50'00"	137°49'00"	17	coarse
2	974	38°16.3'	144°44.7'	5	
3	1704	38°16.12'	145°24.52'	12	
	1722	38°16.23'	145°15.45'	9	
	1723	38°17.07'	145°14.86'	14	
	1724	38°18.56'	145°14.72'	18	
	1727	38°21.17'	145°15.93'	9	
	1731	38°25.83'	145°19.28'	8	
	1733	38°23.09'	145°27.31'	10	
	1735	38°21.60'	145°30.59'	9	

1. Upper Spencer Gulf Benthic Survey (South Australia)
2. Port Phillip Environmental and Benthic Survey (Victoria)
3. Western Port Bay Environmental Study (Victoria)

(1961, 1967) records of *T. forbesii* from South Africa are also referable to *T. olens*.

In *T. antarctica* (28 segments, 24 setigers), notopodial and neuropodial lobes are not mentioned, nor are there any figures by which one might ascertain whether they are present; the setae are described as 'long, slender and capillary'; the annulations of the segments are different (the first 16–17 segments are triannulate, followed by six biannulate segments, whereas in *T. oksae* segments 4–19 are triannulate followed by three biannulate segments); and each segment is crossed by circlets of papillae, "resembling closely strung beads". *T. brevis* (26–27 segments, 24–25 setigers) differs by its hirsute setae and by the nephridial pores being situated on segments 7–25. *T. chiloensis* (27 segments, 24 setigers) has two pairs of notopodial and neuropodial lobes starting at segment 20 or 21. In *T. kerguelenensis* (23–27 segments, 21–23 setigers) segments 4–18 are biannulate; there are no triannulate segments; the posterior margins of the posterior 5–6 segments are strongly crenulated or lobed. *T. doellojuradoi* differs from *T. kerguelenensis* only by its deep purple colour when alive (black in alcohol).

Apart from *T. olens* and *T. oksae*, the only other *Travisia* recorded from Australia is *T. lithophila* Kinberg, 1866, known by two specimens (47, 48 mm) from New South Wales (Kinberg 1866, Hutchings & Murray 1984). This species differs from all the above in its greater number of setigers (44, 53); its notopodial and neuropodial lobes begin on setiger 12, and as in *T. olens* its setae are finely hispid.

Etymology

Named after Ene-mai Oks, collector of the type series.

Distribution and ecology

Travisia oksae is so far known from three areas of sheltered coastal waters in southern Australia: upper Spencer Gulf, South Australia (eight stations from 32°35'S to 32°50'S, in medium to coarse sand at 5–17 m), Port Phillip Bay, Victoria (a single station, 974, just inside entrance, in sand at 5 m) and Western Port Bay, Victoria (eight stations, all in sand).

Acknowledgments

We thank Ene-mai Oks, South Australian Department of Environment and Planning, for depositing at the South Australian Museum the extensive series of polychaetes collected during the Upper Spencer Gulf Benthic Survey of 1985–1987, Mr Timothy Stranks, Museum of Victoria, for the loan of additonal material of *Travisia oksae* sp. nov., and Dr Keith Probert, University of Otago, for information on Allan's Beach, type locality of *Euzonus otagoensis* Probert.

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REVISION OF THE PENNATULACEAN GENUS *SARCOPTILUS* (COELENTERATA: OCTOCORALLIA), WITH DESCRIPTIONS OF THREE NEW SPECIES FROM SOUTHERN AUSTRALIA

GARY C. WILLIAMS

WILLIAMS, G. C. 1995. Revision of the pennatulacean genus *Sarcoptilus* (Coelenterata: Octocorallia), with descriptions of three new species from southern Australia. *Records of the South Australian Museum* **28**(1): 13–32.

The pennatulacean genus *Sarcoptilus* Gray, 1848 from southern Australia and New Zealand is revised. Three previously named species assignable to the genus are reassessed and two of these are described from recently collected material. One of these three taxa is here recognized as valid (*S. grandis* Gray, 1848), one is relegated to synonymy (*S. roseum* Broch, 1910), while the validity of the third is questionable at present (*S. bollonsi* Benham, 1906). In addition, three new species are described (*Sarcoptilus nullispiculatus*, *S. rigidus*, and *S. shaneparkeri*), making a total of five species known—four considered valid taxa from southern Australia and one of questionable validity from New Zealand. A dichotomous key to the species is included as well as a complete list of all pennatulacean species presently known to occur in southern Australia.

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During the 1980's and early 1990's, a relatively large collection of pennatulacean coelenterates was collected from southern Australia. From this work as well as the literature, nineteen species of sea pens are here recorded as occurring in southern Australia and New Zealand (see Table 1). Five species of *Sarcoptilus* (family Pteroeididae) are here treated from southern Australia and New Zealand. *Sarcoptilus grandis* Gray, 1848 is a relatively well-known member of the southern Australian fauna. The other two described species assignable to the genus have up until now been poorly known (*Sarcophyllum bollonsi* [Benham, 1906] and *S. roseum* [Broch, 1910]). The latter is here considered synonymous with *S. grandis*, while the former is of questionable validity. In addition, three new species are also described. Southern Australia is here defined as the continental shelf region of southern Western Australia, South Australia, Victoria, Tasmania, and southern New South Wales (i.e. the southern coastal waters extending from Perth to Newcastle). The genus seems to be geographically restricted to between 31° and 48° south latitude in Australia and possibly New Zealand.

Sarcoptilus Gray, 1848 is differentiated from related genera by having siphonozooids restricted to a conspicuous swollen pad at the intersection of the dorsal margin of each polyp leaf with the dorsal edge of the rachis, the absence of spiculiferous rays in the polyp leaves, a well developed axis extending throughout most of the length of the colony, and the presence of mesozooids on the distal/ventral portion of the rachis. *Sarcophyllum* Kölliker, 1869 is considered synonymous with *Sarcoptilus* by Williams (in press).

Gray (1848) and Benham (1906) described new species of sea pens referable to the genus *Sarcoptilus* from Australia and New Zealand, respectively. Broch (1910) and Briggs (1915) identified and described several pennatulacean species from southern Australian coastal waters. Utinomi and Shepherd (1982) briefly reviewed the shallow-water sea pens of southern Australia. Their work represents the only previously published survey of the regional pennatulacean fauna.

To date, material representing the following pennatulacean taxa have been collected from the coastal waters of Western Australia, South Australia, Victoria, Tasmania, New South Wales, and New Zealand, and are housed in the collections of several institutions (see below): *Sarcoptilus*, *Gyrophyllum* and *Pteroeides* (Pteroeididae); *Pennatula* (Pennatulidae); *Sclerobelemnon* (Kophobelemnidae); *Funiculina*

TABLE 1. Pennatulaceans from southern Australia and New Zealand.

Species	Distribution & Depth (m)	References
Anthoptilum grandiflorum	SA/VIC/NSW/TAS (392–1157)	present work
Funiculina quadrangularis	SA/TAS(520–597)	present work
Gyrophyllum sibogae	TAS (520)	present work
Halipteris willemoesi	TAS (520)	present work
Pennatula fimbriata	possibly Australia	von Kölliker, 1872 as *Leioptilus grayi*; Batie, 1972
Pennatula phosphorea	SA/TAS(436–636)	present work
Pteroeides elegans	NSW (40–110)	Briggs, 1915
Pteroeides hymenocaulum	WA (11–12)	Broch, 1910
Pteroeides multiradiatum	SA (40–50)	Utinomi & Shepherd, 1982
Pteroeides sp.	NZ (0–5)	present work
Ptilosarcus sinuosus (probably synonymous with *Pennatula fimbriata*)	possibly Australia	Batie, 1972
Sarcoptilus bollonsi	NZ (73)	Benham, 1906 & 1907
Sarcoptilus grandis	WA/SA/V/NSW (10–146)	Gray, 1860; Briggs, 1915, Utinomi & Shepherd, 1982; present work
Sarcoptilus nullispiculatus	SA/V/NSW (18)	Utinomi & Shepherd, 1982; present work
Sarcoptilus rigidus	WA (depth?)	present work
Sarcoptilus shaneparkeri	WA/SA (6–18)	Utinomi & Shepherd, 1982; present work
Sclerobelemnon schmeltzi	NSW (40–110)	Briggs, 1915
Umbellula sp.	NZ (449–4066)	present work
Virgularia gracillima	NZ (18–20)	von Kölliker, 1880; Dendy, 1896; Benham, 1907.
Virgularia gustaviana	WA/SA (depth?)	Utinomi & Shepherd, 1982; present work
Virgularia mirabilis	SA/VIC(depth?)	Utinomi & Shepherd, 1982

(Funiculinidae); *Anthoptilum* (Anthoptilidae); *Halipteris* and *Virgularia* (Virgulariidae); and *Umbellula* (Umbellulidae). The material, much of it recently collected, originates mainly from Perth, Albany, Great Australian Bight, Spencer Gulf, Gulf St Vincent, several localities off Victoria, New South Wales, and Tasmania, as well as the South Island of New Zealand.

The material (including types) used in this study is deposited at the South Australian Museum, Adelaide (SAM); Western Australian Museum, Perth (WAM); New Zealand Oceanographic Institute (NZOI), Wellington; and the California Academy of Sciences—Department of Invertebrate Zoology and Geology, San Francisco (CASIZG). Terminology used in the present work conforms to that of Bayer, Grasshoff, and Verseveldt (1983).

All figures in the present work are by the author.

Key To The Species Of *Sarcoptilus*

1 — Sclerites absent altogether..... .....*S. nullispiculatus* sp. nov
— Sclerites present, mostly relatively densely distributed.....2
2 — Basal region of peduncle without robust otolith-like sclerites.....*S. shaneparkeri* sp. nov.
— Basal region of peduncle with numerous robust otolith-like sclerites in the interior, 0.2–1.2 mm long.....4
3 — Colonies stiff and rigid. Polyp leaves thick,

swollen, and turgid, fan-shaped to rectangular or trapezoidal, <6 mm in length. Total colony length <120 mm.....*S. rigidus* sp. nov.

— Colonies flexible to limp. Polyp leaves flattened or thin, not turgid, semi-circular to kidney-shaped, up to 45 mm in length. Total colony length up to 350 mm.....*S. grandis* Gray, 1848

Systematic Account

Family PTEROEIDIDAE Kölliker, 1880

Sarcoptilus Gray, 1848

Sarcoptilus Gray, 1848: 45 (in part). Gray, 1860: 23 (in part).

Sarcophyllum Kölliker, 1869: 224. Leuckart, 1872: 280.

Kükenthal & Broch, 1911: 441. Kükenthal, 1915: 117.

Pteroeides Balss, 1910: 60 (in part).

Diagnosis

Colonies feather-like and stout. Bilateral symmetry throughout length of rachis. Axis extends throughout entire length of colony, and round in cross secton. Polyp leaves present and conspicuous, rounded on margins, mostly kidney-shaped or fan-shaped. Polyp leaves without rays. Autozooids congested on distal margin of polyp leaves. Anthocodiae small, retractile into their basal protuberances. Siphonozooids restricted to swollen pads at base of each polyp leaf where the polyp leaves join rachis. Proximal surfaces of polyp leaves devoid of siphonozooids. Mesozooids usually present on distal ventral portion of rachis in a single longitudinal row or scattered. Sclerites smooth, not three-flanged. Spindles or rods of polyp leaves do not form rays; long needles absent. Rods or flattened rods present in the rachis. Small ovoid or biscuit-shaped plates or rods may occur in peduncle.

A genus of five species: southern Australia (four valid species) and New Zealand (one species of questionable validity).

TABLE 2. Table of comparative characters for the genus *Sarcoptilus*

Species	Colour (In alcohol)	Peduncular Sclerites	Maximum Length (mm)	Polyp Leaf Shape	Polyp Leaves Per Side
S. bollonsi (based on the original description)	pale reddish	large calcareous bodies in the interior	155	sickle or fin-shaped	30
S. grandis	cream-white to pale yellow or rose	ovoid finger-biscuits, rods or spindles, & otolith-like forms	350	semi-circular, kidney-shaped, or crescent-shaped	32–36
S. nulli-spiculatus	apricot to pale orange	absent	74	semi-circular, or fin-shaped	18–30
S. rigidus	cream-white	robust spindles & otolith-like forms	117	fan-shaped, rectangular to trapezoidal	22–26
S. shane-parkeri	blue-grey	stout rods & minute ovals	120–180	triangular or fin-shaped to semi-circular	22–38

Sarcoptilus bollonsi (Benham, 1906) new comb.

Sarcophyllum bollousi Benham, 1906: 66 (misspelling—originally named for Captain Bollons of the Government steamship 'Hinemoa').

Sarcophyllum bollonsi Benham, 1907: 193.

Remarks

I have not been able to locate the type specimen for this species and I do not know of any specimens that can be identified as *Sarcoptilus bollonsi*. The species is known only from the descriptions of Benham (1906, 1907), and apparently has not been collected since. From Benham's descriptions, it is very difficult to distinguish this species from *Sarcoptilus grandis*. In my opinion, the descriptions and figures are not detailed enough to distinguish the species. I therefore have not included it in the key to the species of *Sarcoptilus*.

At least two specimens of a species of pteroeidid sea pen closely resembling *Pteroeides dofleini* (Balss, 1909) (see d'Hondt, 1984: 18) have recently been collected from near the type locality of *Sarcoptilus bollonsi* from 0–5 metres depth by the New Zealand Oceanographic Institute (NZOI O840 and NZOI Q97). These specimens superficially resemble members of the genus *Sarcoptilus*. It is possible that the two taxa may be confused.

It is necessary to examine type material of *Sarcoptilus bollonsi* in order to make a sound assessment of its taxonomic status.

Distribution

New Zealand (southwestern coast of the South Island). Recorded only from the type locality at Doubtful Sound in 73 metres of water.

Sarcoptilus grandis Gray, 1848

(Figs 1–5)

Sarcoptilus grandis Gray, 1848: 45. 1860: 23. 1870: 25. Utinomi & Shepherd, 1982: 209.

Sarcophyllum australe Kölliker, 1870: 229. 1872: 186. Hickson, 1890: 140. Thomson & Mackinnon, 1911: 694.

Sarcophyllum grande Kölliker, 1880: 2. Balss, 1910: 60. Kükenthal & Broch, 1911: 441. Briggs, 1915: 93. Kükenthal, 1915: 118.

Sarcophyllum roseum Broch, 1910: 117. Kükenthal, 1915: 118, 120. ***syn. nov.***

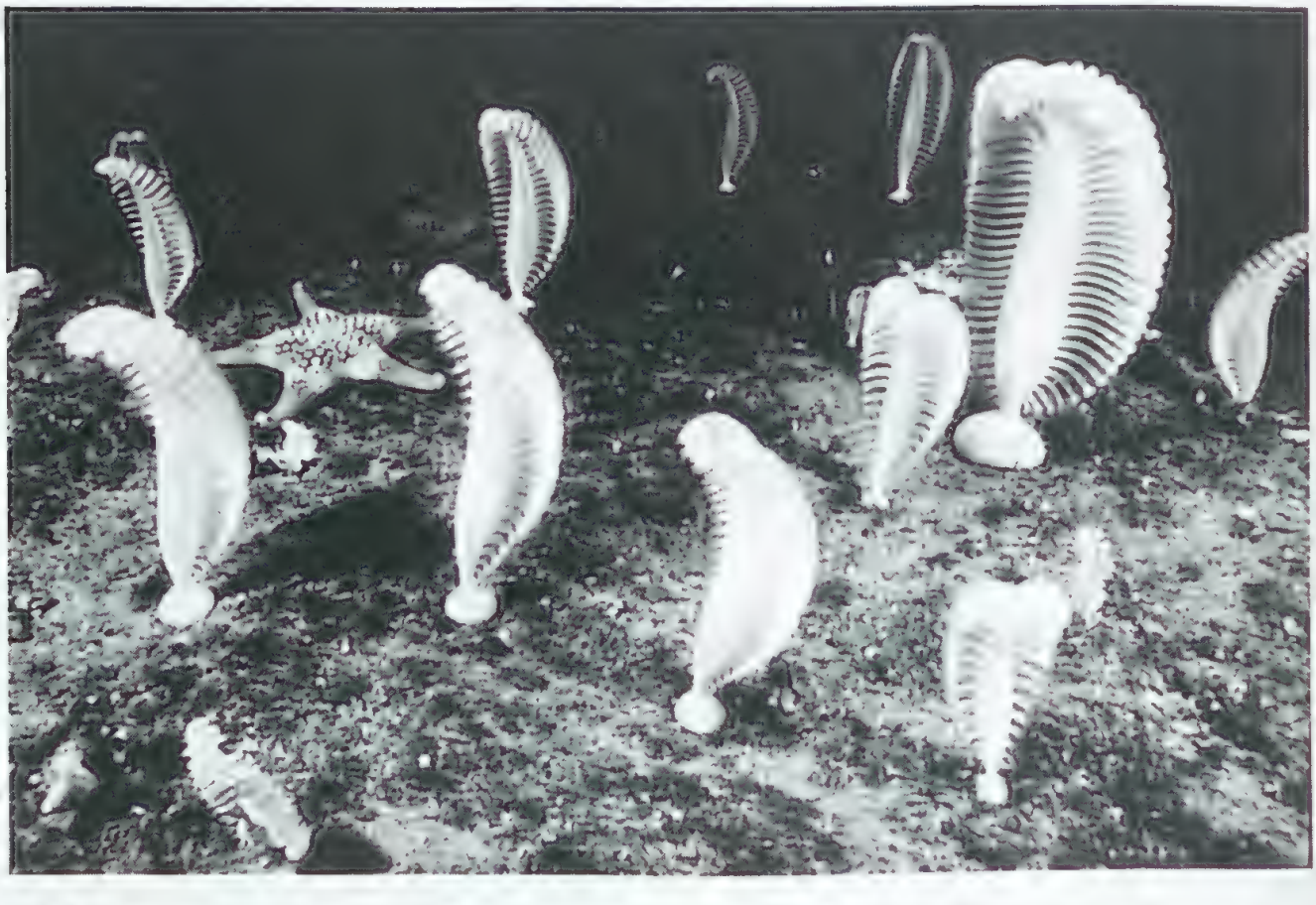

FIGURE 1. *Sarcoptilus grandis*. Underwater photograph of several living sea pens. Photograph: Fred Bavendam.

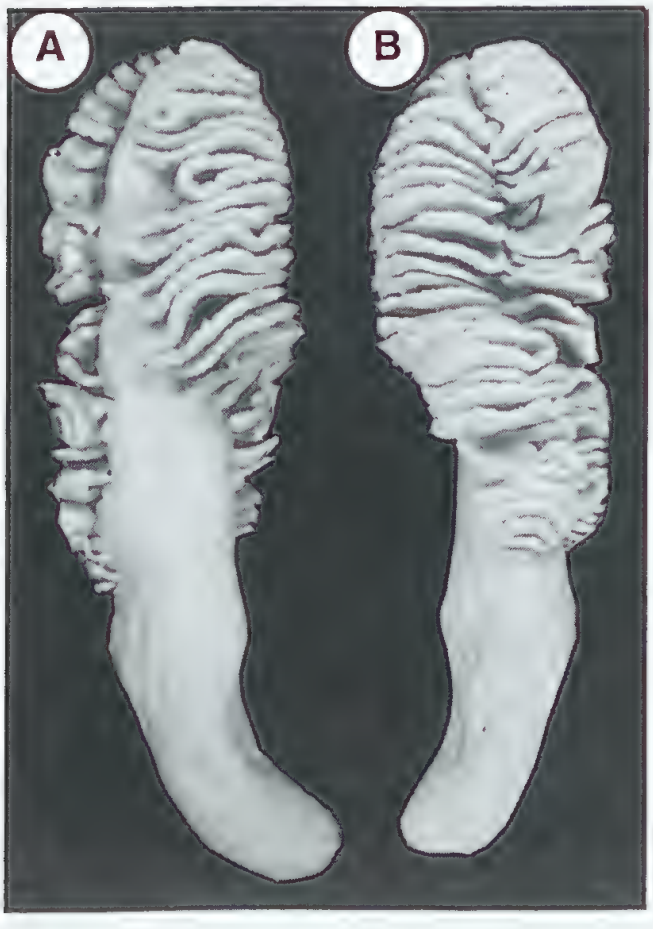

FIGURE 2. *Sarcoptilus grandis*. Photographs of a single specimen, 170 mm in length (SAM H11919). **A**, Dorsal view; **B**, Ventral view.

Material

South Australia: SAM–10931 (H195), Great Australian Bight, Ceduna District (32°24'S, 133°30'E), 49 metres depth, 23 August 1973, P. Symonds (collector), 2 specimens. SAM–H11919 (H771), Great Australian Bight, near Ceduna (32°24'S, 133°24'E), 26 October 1973, P. Symonds (collector), 1 specimen. SAM–H11920 (H774), Spencer Gulf: 15 km S of Cowell, Stn 10X (34°0'S, 136°56'30"E), 28 September 1981, (N.A. Carrick (collector), 1 specimen. SAM–H11922 (H785), Gulf St Vincent, Adelaide District: Hallett's Cove, 1 specimen. CASIZG–088073, Spencer Gulf, ca 1.5 Nm NW of Point Riley (33°52'S, 137°35'E), 20–25 metres depth, FV Kara George (prawn trawler), 14–15 December 1988, K. L. Gowlett-Holmes and P. Briggs (collectors), 5 specimens. CASIZG–088074, Gulf St Vincent, Adelaide, 4 miles SW of end of Outer Harbour, 12 metres depth, 27 June 1965, P.D. Mitchell (collector), 2 specimens. CASIZG–091432, Gulf St Vincent, Port Noarlunga Beach, 20 January 1964, Mr. Castleton (collector), 1 specimen. **Western Australia:** WAM–65–59, King George Sound, just outside entrance to Oyster Harbour, 4.6 metres depth, 7 January 1959, 1 specimen. WAM–68–59, Albany, Emu Point Channel, 4.6 metres depth, 15 January 1959, 1 specimen. WAM–707–91, Western Australia, Albany, Oyster Harbour ca 6 metres depth, 17 July 1965, E. P. Hodgkin (collector), 1 specimen. WAM–517–88, Esperance, between Sandy Hook Island and Cape LeGrande, 31–35 metres depth, 23–25 June 1986, A. Longbottom on LFBE 'Triumph' (collector), 1 specimen. WAM–67–59, Albany, Emu Point Channel, 4.6 metres depth, 15 January 1959, 1 specimen. WAM–706–91, Albany, Middleton Beach, beached after storm, 5–7 August 1984, V. Milne (collector), 8 specimens. **Tasmania:** SAM–H–13071, Port Davey, Bathurst Channel, S Point of Sarah Channel, 10–12 metres depth, 3 April 1993; W. Zeidler, K. L. Gowlett–Holmes, F. A. Bavendam (collectors), 4 specimens. SAM–H13072, Port Davey, Bathurst Channel, 6–10 metres depth; W. Zeidler, K. L. Gowlett-Holmes, F. A. Bavendam (collectors), 2 specimens.

Description

Specimens examined range in length from 115–350 mm. Additional material in South Australian Museum collection measured by Shane Parker (late Curator of Lower Marine Invertebrates) ranges between 165 and 325 mm in length. Rachis comprises 50–72% of total colony length. Polyp leaves semi-circular or kidney-shaped (usually 25–50 mm in length and up to 30 mm in width), relatively thin (mostly 2–4 mm thick), and number approximately 32–36 per side. Autozooids are small, conical in shape, and congested in several rows (usually 10–15) that form a band along the distal margin of each polyp leaf, extending to approximately 5 mm down each side of a particular leaf. Each autozooid approximately 1.0 mm in length and 0.6 mm in width. Siphonozooids restricted to swollen pad at border between base of each polyp leaf and rachis. Each pad ovoid to elliptical/oblong in shape and approximately 7 mm long by 4 mm wide. Each siphonozooid minute (approximately 0.07 mm in diameter). Siphonozooids highly congested and cover surface of each pad. In addition, mesozooids present on distal/ventral region of rachis. These circular in shape, approximately 0.6 mm in diameter and are either congested in several indistinct longitudinal rows or disposed more sparsely in a single or double longitudinal row. Retracted mesozooids have minute slit-like aperture, 0.12 mm in length. Sclerites of polyp

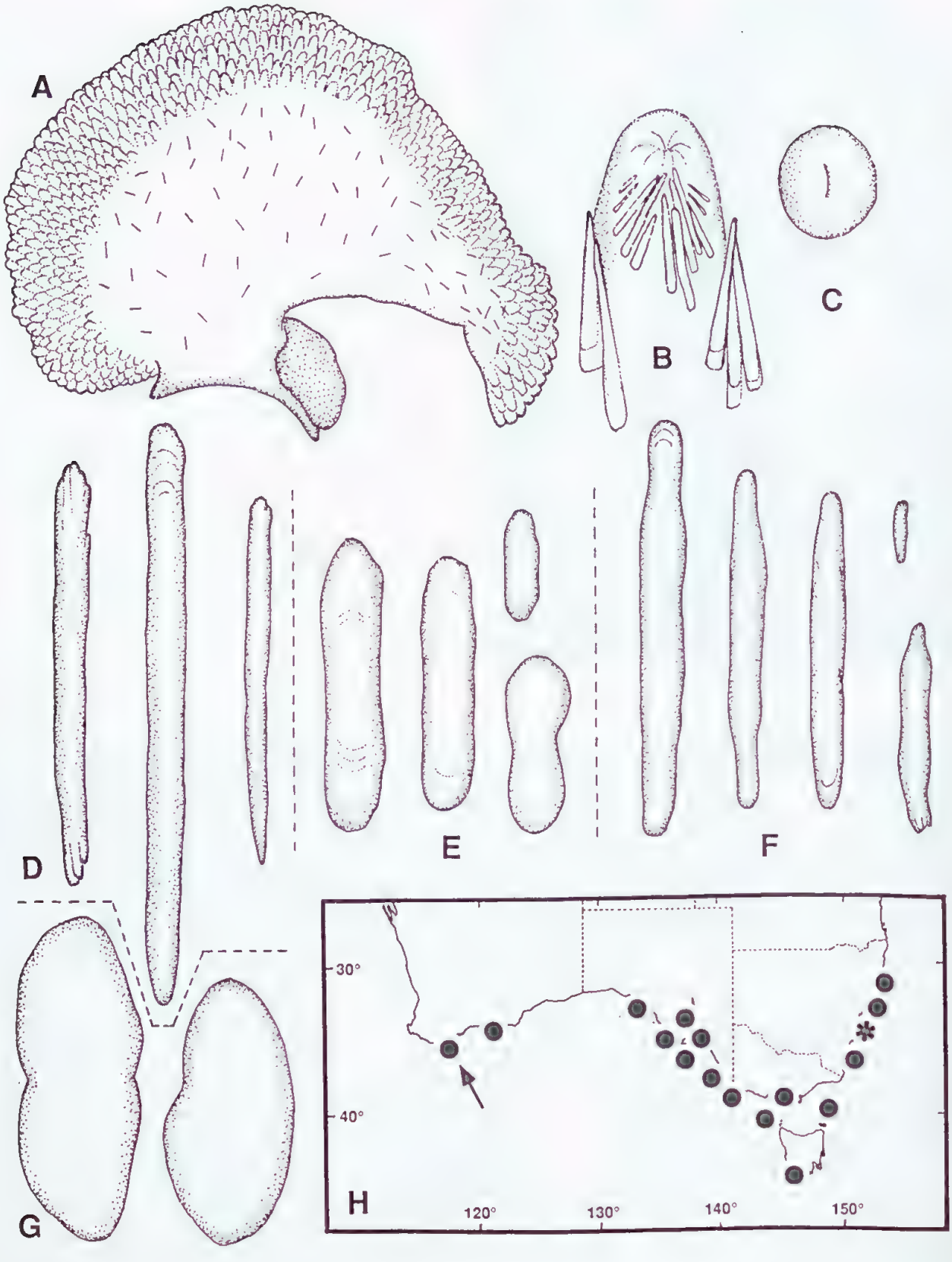

FIGURE 3. *Sarcoptilus grandis*. **A**, Upper surface of a single polyp leaf (39 mm in length), with basal siphonozooid pad; **B**, A single autozooid, maximum width 0.7 mm; **C**, View from above of a single mesozooid, 0.6 mm in diameter; **D**, Polyp leaf sclerites, 1.15 mm. 0.48 mm, 1.25 mm; **E**, Sclerites from the surface of the peduncle, 0.19 mm, 0.17 mm, 0.07 mm, 0.12 mm; **F**, Sclerites from the interior of the upper and middle portions of the peduncle, 0.28 mm, 0.23 mm , 0.21 mm, 0.17 mm, 0.55 mm; **G**, Sclerites of the interior of the lower portion of the peduncle, 1.1 mm, 0.87 mm; **H**, Map showing distribution of the species: ✱ = type locality, ● = other collecting stations; arrow shows type locality of *Sarcophyllum roseum*.

FIGURE 4. *Sarcoptilus grandis*. Scanning electron micrographs of polyp leaf sclerites. **A**, 1.01 mm; **B**, 0.91 mm; **C**, 1.05 mm; **D**, 1.02 mm; **E**, 0.82 mm; **F**, 1.23 mm; **G**, 0.66 mm; **H**, 1.10 mm; **I**, 0.85 mm.

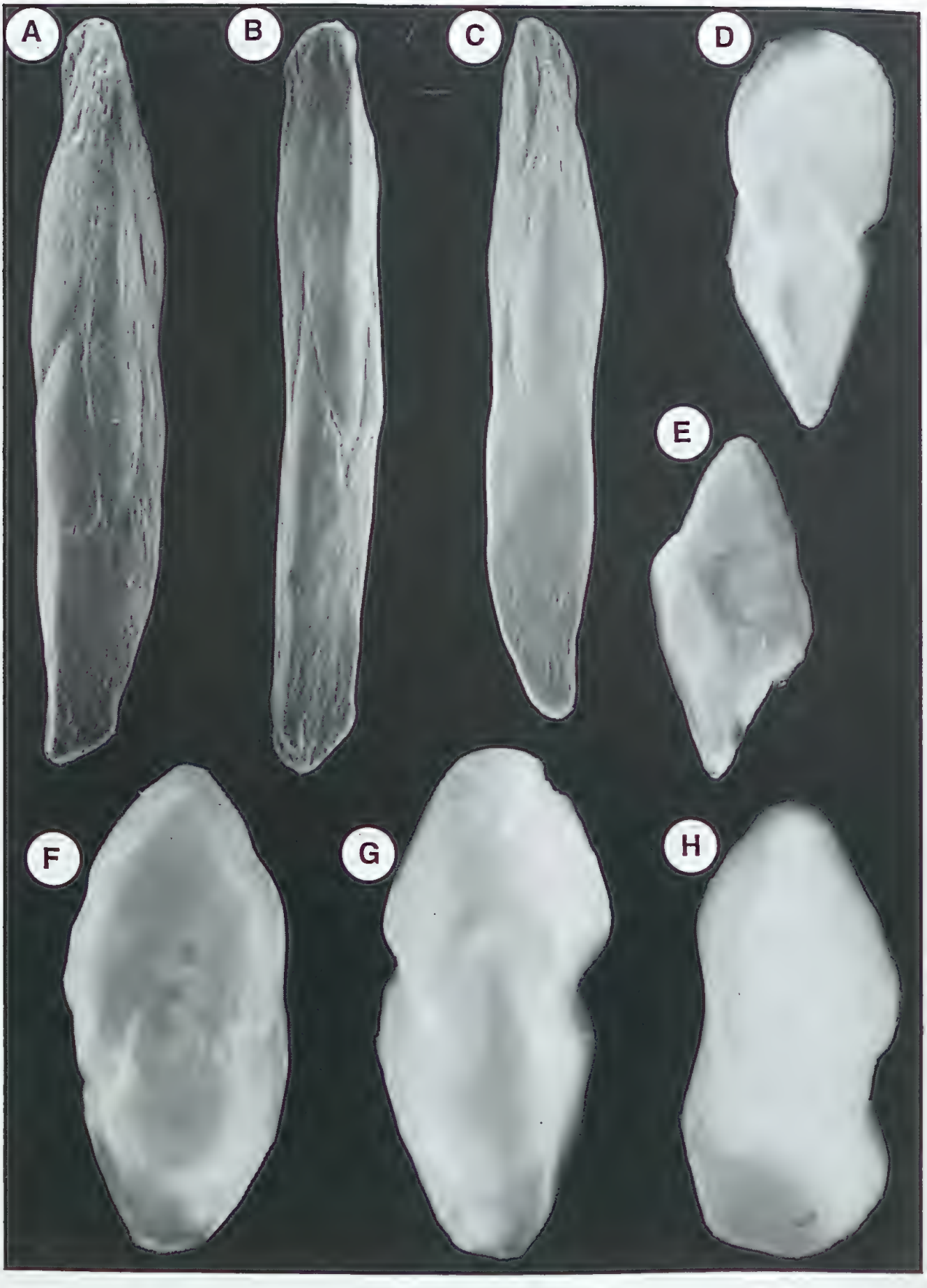

FIGURE 5. *Sarcoptilus grandis*. Scanning electron micrographs of peduncular sclerites. A–C, Sclerites from the interior of the upper and middle portion of the peduncle. **A**, 0.57 mm; **B**, 0.76mm; **C**, 0.53 mm. D–H, Sclerites from the interior of the basal portion of the peduncle; **D**, 0.85 mm; **E**, 0.74 mm; **F**, 1.05 mm; **G**, 0.77 mm; **H**, 0.58 mm.

leaves smooth slender rods or spindles (0.38–1.35 mm in length). Many of these slightly clavate, being enlarged at one end and tapering to a pointed opposite end. Polyp leaf sclerites distributed relatively densely in portion containing autozooids, and very sparse or absent on proximal faces of polyp leaves. Sclerites of surface of polyp leaves often form short lines between groups of autozooids in radiating fashion. Autozooids contain sclerites that either run parallel to longitudinal plain of each autozooid or converge to form inverted 'V' bordering each autozooid. Sclerites of peduncle are of three distinct types—small ovoid fingerbiscuits (0.06–0.19 mm in length) common throughout the surface, stout rods and spindles (0.17–0.76 mm in length) in interior of upper and middle portions of peduncle, and large robust otolith-like forms (0.20–1.1 mm in length) in interior of lower portion near base. Colour in life off-white, orange, or rose; cream or tannish-white preserved in alcohol.

Distribution

Southern Australia (Vicinity of Albany, Western Australia to at least as far as the Manning River/Cape Hawke region, New South Wales); 4.6–146 metres in depth. Utinomi and Shepherd (1982: 211) state the range as being from the Great Australian Bight to southern Queensland. This is by far the most common and widespread species in the genus. Collecting stations for the species come from Briggs (1915), Gray (1860, 1870), Kölliker (1870, 1872, 1880), Hickson (1890), Thomson and MacKinnon (1911), as well as from a large number of recently acquired lots in the collections of the Western Australian Museum, the South Australian Museum, and the California Academy of Sciences. The maximum depth record is reported by Briggs (1915: 94) from King Island, Bass Strait. The type locality was not recorded in the original description by Gray (1848: 45) but only later by Gray (1860: 23 and 1870: 25) as Sydney, Australia.

Discusssion

I have unfortunately not been successful in locating the type specimen of *Sarcophyllum roseum* Broch, 1910 for comparison. However, after having examined a large number of specimens of *Sarcoptilus* from a wide geographic scope, I here conclude that *Sarcophyllum roseum* should be considered as a junior synonym of *Sarcoptilus grandis*. In my opinion, the minor morphological variance observed in *Sarcophyllum roseum*, which was used by Broch to distinguish his species from Gray's, can certainly be accommodated by the range of variation in *Sarcoptilus grandis*. Included in the specimens examined for the present study are several from Broch's type locality (Albany, Western Australia), which agree well in virtually all respects with his original description.

The four characters used by Broch (1910: 121) to distinguish the species are as follows: (1) rachis polyps—forming a long row or plate in *S. grandis* vs a simple or double row in *S. roseum*; (2) the autozooid region of the polyp leaves—in which this polyp zone is wide with numerous sclerites on both sides of the leaf in *S. grandis* vs narrow with sclerites only on the under surface of the leaf in *S. roseum*; (3) the sterile surface of the polyp leaf—with numerous sclerites in *S. grandis* vs no sclerites in *S. roseum*; and (4) length of sclerites from the surface of the rachis and peduncle—rachis sclerites <0.7 mm long and peduncle sclerites <0.4 mm long in *S. grandis* vs <0.5 mm and <0.2 mm respectively in *S. roseum*. These are all variable characters that show gradations between specimens and hence cannot be used to justify the differentiation of two species. An example that contradicts Broch's distinction is a specimen from King George Sound (WAM – 65–59), which has the rachis mesozooids disposed in a plate as in *S. grandis*, but is without sclerites in the sterile portion of the polyp leaf as in *S. roseum*. I conclude that *Sarcophyllum roseum* and *Sarcoptilus grandis* are morphologically indistinguishable and therefore conspecific.

Apparently a substantial amount of variation is present in the size of the peduncular sclerites. Kükenthal (1915: 119) recorded sclerites from the interior as large as 4.5 mm in length, and those from the surface up to 0.4 mm long.

Sarcoptilus nullispiculatus sp. nov.

(Figs 6, 7A,B)

?*Sarcoptilus* sp. Utinomi & Shepherd, 1982: 211.

Material

Holotype. SAM–H10929A, South Australia: Gulf St Vincent, Adelaide District, Port Stanvac, 18 metres depth, D. Cooper (collector), 1 whole specimen.

Paratype. SAM–H10929B, same data as holotype, 1 whole specimen.

Other material studied. SAM–H10929C, same data as holotype, 1 whole specimen.

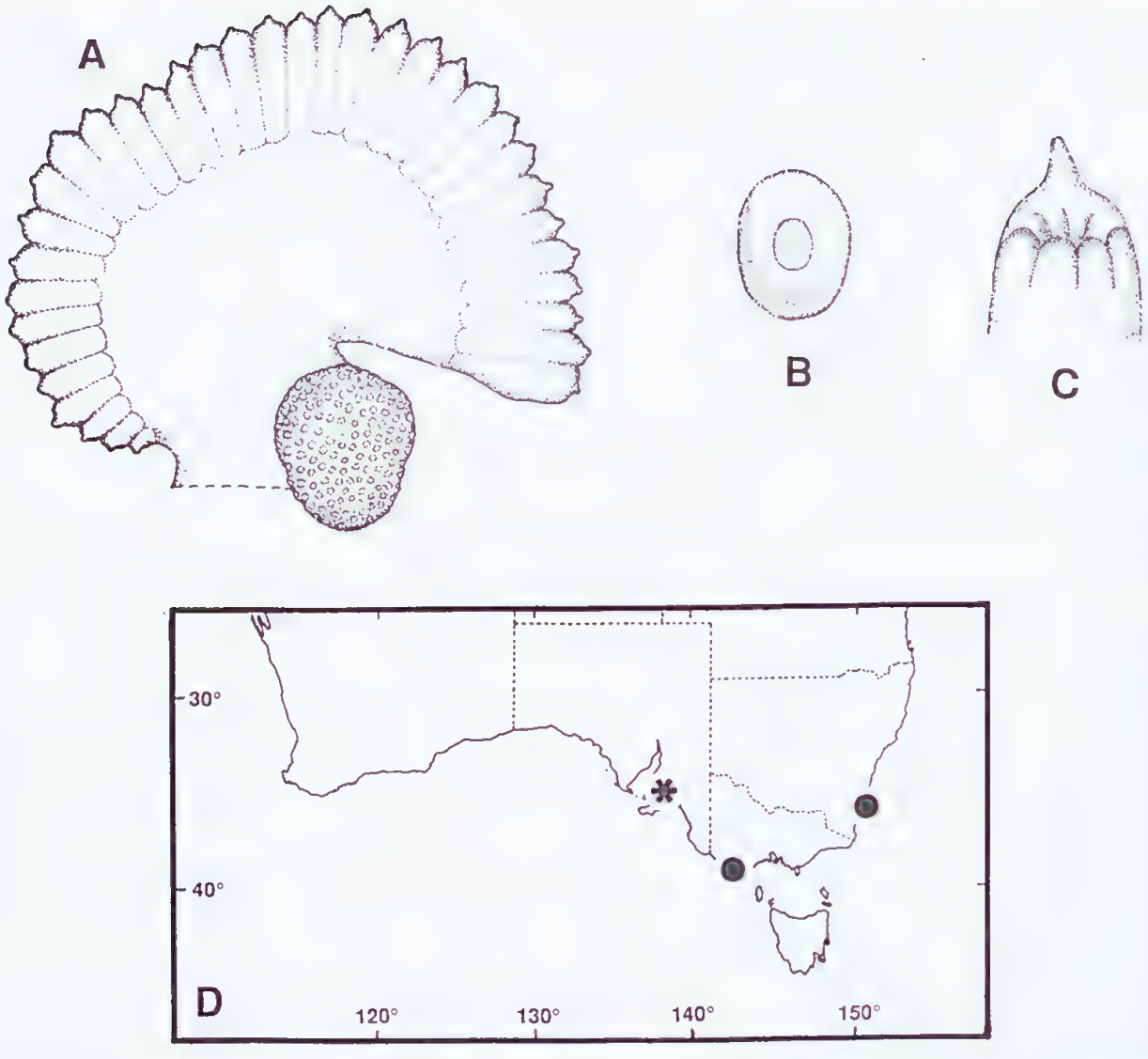

FIGURE 6. *Sarcoptilus nullispiculatus*. **A**, Lower surface of a single polyp leaf (6 mm in length), with siphonozooid pad; **B**, View from above of a single mesozooid, 0.45 mm in length; **C**, Distal portion of a single autozooid, 0.6 mm in width; **D**, Map showing distribution of the species; ✱ = type locality, ● = localities reported by Utinomi and Shepherd (1982) for *Sarcoptilus* sp.

Diagnosis

Colonies under 75 mm in length, slender and limp. Rachis and peduncle roughly equal in length. Polyp leaves 18–30 per side, fin-shaped to semi-circular, <7 mm in length. Autozooids in 1–2 rows, 25–36 per leaf. Siphonozooids restricted to circular pads at dorsal base of each leaf. Single longitudinal row of up to 20 mesozooids present on ventral/distal surface of rachis. Sclerites absent altogether. Colour orange or pale-salmon in alcohol.

Description

The three specimens examined range in length from 58–74 mm. Holotype is 68 mm long while paratype is 74 mm in length. Colonies are slender and flaccid. Rachis comprises 47–58% of total colony length. Dorsal side of rachis has a medial longitudinal groove for its entire length. Polyp leaves number 18–30 per side, fin-shaped to semi-circular, each leaf up to 7 mm in length. Autozooids disposed in one or two rows along distal margin of each leaf, and number approximately 25–36 autozooids per leaf. Each autozooid 0.4–0.6 mm in diameter. Most autozooids have a single non-spiculated, flexible, nipple-like protuberance projecting distally from their apices. Siphonozooids contained on circular to ovoid pads, 1.5 mm in diameter, on the dorsal base of each polyp leaf adjacent to lateral margin of rachis. Each siphonozooid approximately 0.07 mm in diameter. In addition, a single medial row of 10–20 mesozooids present on distal/ventral portion of rachis, each mesozooid 0.20–0.45 mm

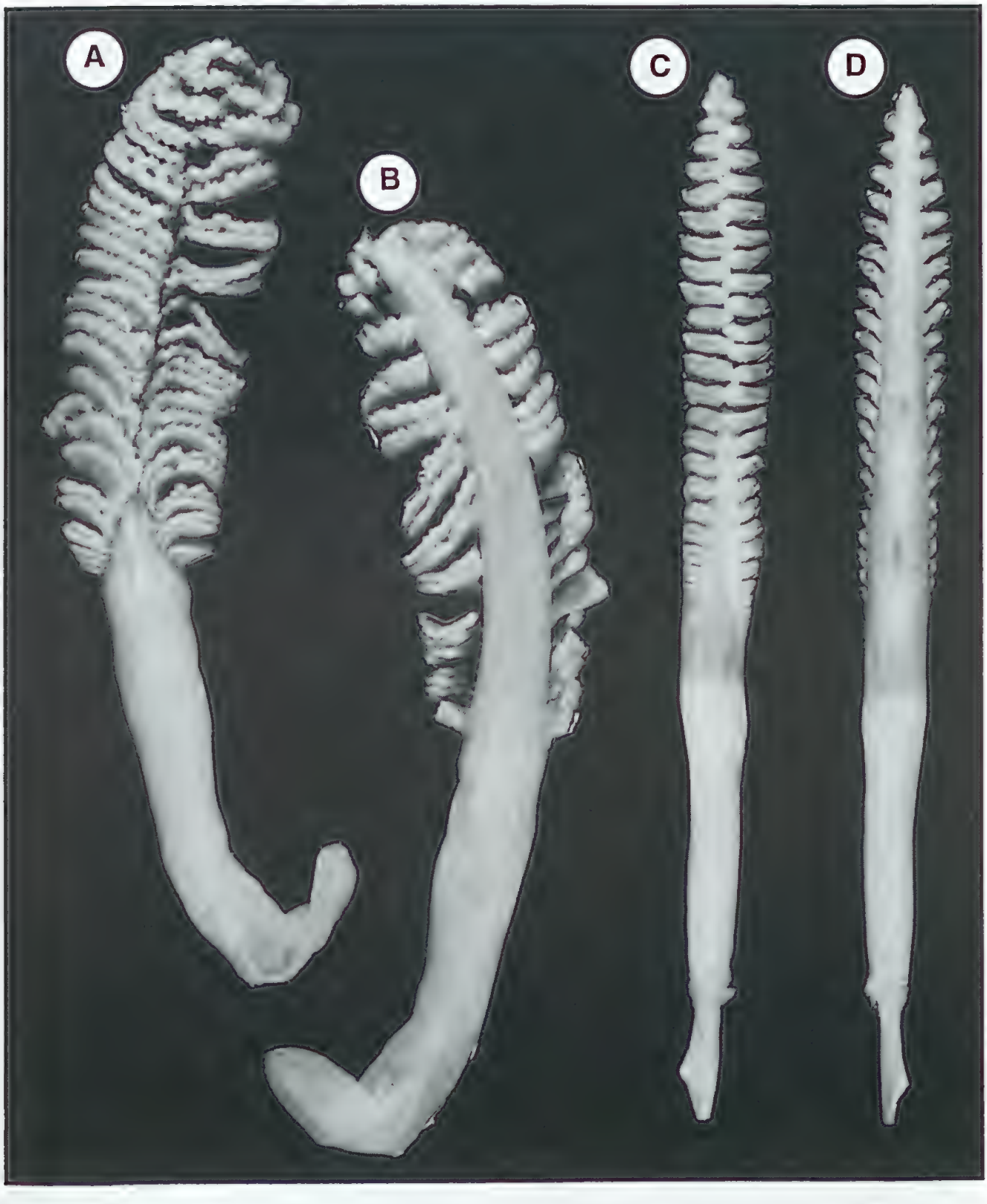

FIGURE 7. Photographs of holotypes. A,B. *Sarcoptilus nullispiculatus*. **A**, Ventral view; **B**, Dorsal view. C,D. *Sarcoptilus rigidus*; **C**, Ventral view; **D**, Dorsal view.

in diameter. Sclerites apparently absent altogether from all parts of colonies. Colour throughout apricot-orange to pale orange in alcohol.

Etymology

The specific epithet is derived from the Latin, *nullus* = not any or none, and *spiculum* = a point or dart; in reference to the lack of sclerites in this species.

Distribution

Southern Australia (Gulf St Vincent, South

Australia, and possibly Pt Fairy, Victoria to Jervis Bay, New South Wales—as reported by Utinomi & Shepherd, 1982); 18 metres in depth. Type locality is Gulf St Vincent, South Australia.

Discussion

This species is differentiated from other members of the genus by a complete lack of sclerites. It is likely that *Sarcoptilus* sp. of Utinomi and Shepherd (1982) is conspecific with this species. Even though they do not mention the lack of sclerites in this species, their description agrees in all other aspects with the present material.

Sarcoptilus rigidus sp. nov.

(Figs 7C,D, 8, 9)

Material

Holotype. WAM–363–31, Western Australia: vicinity of Perth: Cottesloe Beach, 1 whole specimen.

Paratype. WAM–364–31, same data as holotype.

Other material studied. WAM–714–91, Western Australia: Albany: Middleton Beach, beach drift, 10 August 1991, S. Bolton (collector), 1 specimen.

Diagnosis

Colonies stiff and rigid, dart-shaped. Polyp leaves thick and turgid, fan-shaped to rectangular or trapezoidal; <6 mm in length; 22–26 leaves per side of rachis. Autozooids in single row of 25–30 per polyp leaf. Several mesozooids scattered on ventral distal extremity of rachis. Siphonozooid pad conspicuous and kidney-shaped. Peduncular sclerites: robust spindles in upper part (0.25–0.42 mm long) and robust, ovoid, otolith-like bodies (0.3–1.2 mm long) in lower part. Colour in alcohol uniformly cream-white or bicoloured with rachis grey and peduncle cream-white.

Description

Specimens examined dart-shaped, markedly stiff and rigid, 65–117 mm in length. Holotype is 80 mm long and paratype 65 mm in length. Peduncle makes up approximately 38–43% of total length. Axis extends throughout entire length of each specimen. Polyp leaves thick and turgid, fan-shaped to rectangular or trapezoidal with rounded corners, 3–6 mm in length. 22–26 polyp leaves per side. Autozooids completely retractile and disposed in single row at distal margin of each polyp leaf, generally 25–30 per polyp leaf. Each retracted autozooid has slit-like aperture, perpendicular to plane of polyp leaf. This aperture surrounded by slightly ovoid ring-like basal swelling without teeth. Siphonozooids contained on swollen, more-or-less elliptical to kidney-shaped pads at dorsal base of each polyp leaf, adjacent to lateral margin of rachis. Each siphonozooid pad approximately 1.5–3.0 mm in length, while an individual siphonozooid is approximately 0.1 mm in diameter. In addition, several mesozooids scattered on distal ventral extremity of rachis, each approximately 0.3–0.5 mm in diameter. Upper and lower surfaces of polyp leaves densely or sparsely ornamented with sclerites that are mostly longitudinally disposed in parallel. Sclerites of polyp leaves slender elongate rods and spindles, 0.3–1.3 mm in length. Many of these faintly longitudinally grooved, some rounded on ends while others angled and obliquely truncate at ends. Sclerites of rachis similar to those of polyp leaves, sparsely distributed. Sclerites of upper portion of peduncle smooth robust spindles, 0.25–0.42 mm in length. These tapered to rounded on ends and often slightly constricted in middle. Lower part of peduncle contains ovoid otolith-like bodies, 0.3–1.2 mm in length. Most of these robust with rounded ends, and many somewhat constricted in middle. Colonies vary in colour in alcohol from bicoloured—rachis grey with peduncle cream-white, to monochromatic—entirely cream-white.

Etymology

The specific epithet is derived from the Latin *rigidus* = stiff or rigid; in reference to the rigid and turgid nature of the colonies of this species.

Distribution

Western Australia (Perth and Albany); shallow sublittoral (depth range unknown). This species is known from only three specimens collected at two localities. The type locality is Perth, Western Australia.

Discussion

This species differs markedly from other members of the genus by its remarkably rigid form and conspicuously turgid polyp leaves. The only other species containing similar otolith-like sclerites in the peduncle is *Sarcoptilus grandis*.

The density of spiculation on the polyp leaves varies greatly from very dense (and covering the entirety of both surfaces) in the holotype and paratype, to very sparse in the specimen from

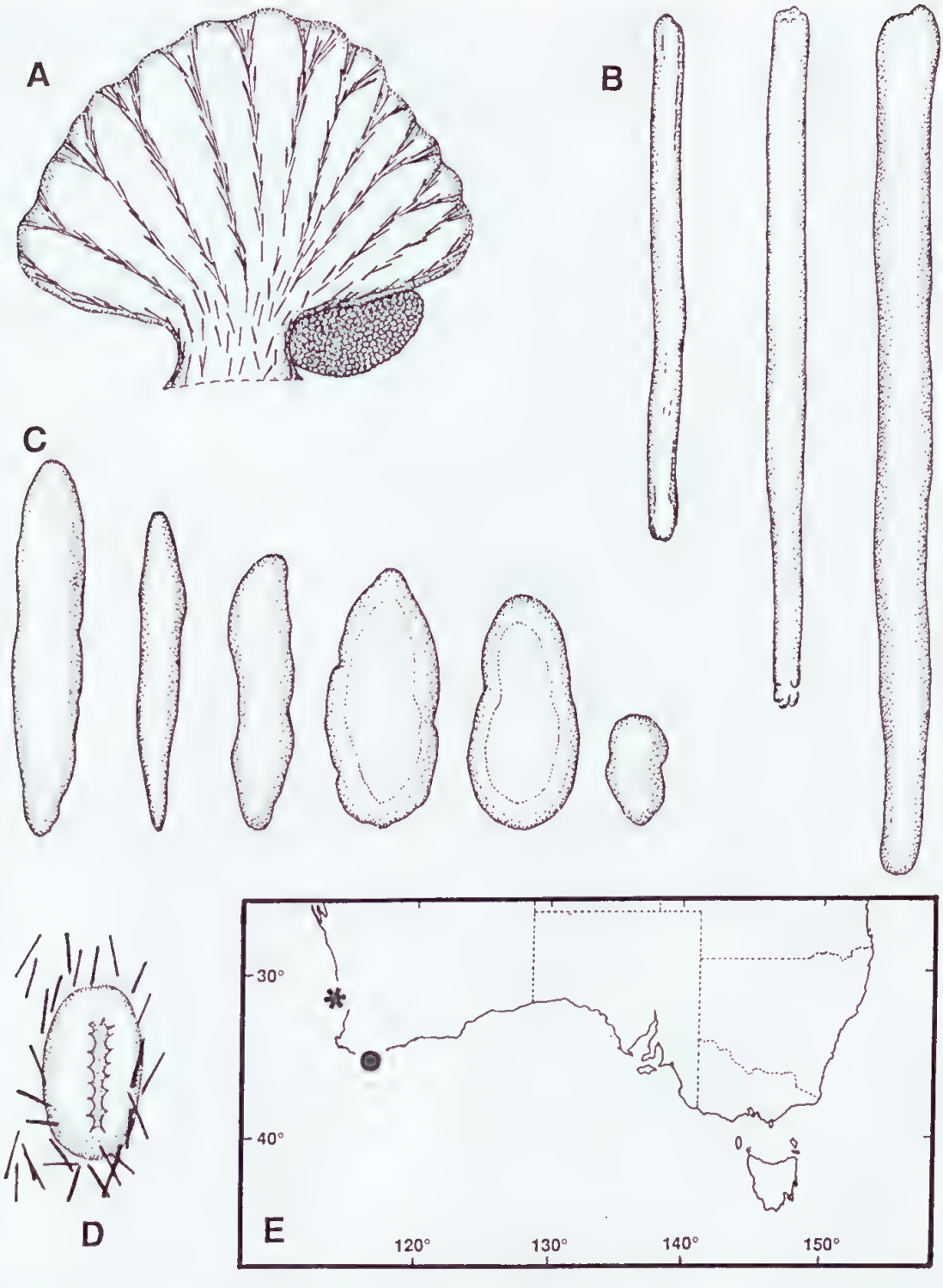

FIGURE 8. *Sarcoptilus rigidus*. **A**, Ventral view of a single polyp leaf (4 mm in length), with siphonozooid pad; **B**, Polyp leaf sclerites, 0.95 mm, 1.30 mm, and 0.40 mm in length; **C**, Peduncular sclerites, 0.27 mm, 0.42 mm, 0.35 mm, 1.2 mm, 1.0 mm, and 0.5 mm in length; **D**, View from above of a single autozooid, 0.27 mm in length; **E**, Map showing distribution of the species: ✱ = type locality; ● = other locality.

Albany, in which only a few sclerites are scattered in the distal margin of each leaf just below the autozooids.

Sarcoptilus shaneparkeri sp. nov.

(Figs 10–13)

Scytalium sp. Utinomi & Shepherd 1982: 209.

Material

Holotype. SAM–H10923A, South Australia: upper Spencer Gulf: 1.6 km E of Douglas Point, 17 metres depth, May 1988, N. Holmes (collector), 1 whole specimen.

FIGURE 9. *Sarcoptilus rigidus*. Scanning electron micrographs. A–C, Sclerites of the polyp leaves. **A**, 0.99 mm; **B**, 0.33 mm; **C**, 0.41 mm. D–G; Sclerites of the peduncle. **D**, 0.77 mm; **E**, 0.54 mm; **F**, 0.73 mm; **G**, 0.86 mm.

Paratype. SAM–H10923B, same data as holotype, 1 whole specimen.

Other material studied. **South Australia:** SAM–H10922, upper Spencer Gulf, 1.6 km E of Douglas Point (Kinhill Survey Station 3A), 17 metres depth, May 1988, N. Holmes (collector), 11 specimens. SAM–H10924, upper Spencer Gulf: 1.6 km E of Douglas Point (Kinhill Survey Station 3A), 17 metres depth, May 1988, N. Holmes (collector), 1 specimen. SAM–H10926,

FIGURE 10. *Sarcoptilus shaneparkeri*. Photographs of holotype. **A**, Ventral view; **B**, Dorsal view.

upper Spencer Gulf: 1600 m E of Douglas Point; 27 June 1988, N. Holmes (collector), 3 specimens. SAM–H11842, Spencer Gulf, 22 km S of Port Augusta, 10 metres depth, 3 February 1983, R. Henderson (collector), 1 specimen. SAM–H10918, Spencer Gulf between Douglas Point and Mambray Creek, 15–18 metres in depth, June 1987, N. Holmes (collector), 1 specimen. SAM–H10920, Spencer Gulf between Douglas Point and Mambray Creek, 15–18 metres depth, June 1987, N. Holmes, 2 specimens. SAM–H10921, upper Spencer Gulf, 1.6 km E of Douglas Point, 15 metres depth, 5 May 1988, N. Holmes, 1 specimen. SAM–H10917, upper Spencer Gulf, S of Redcliff Point, 15 metres depth, 9–11 April 1980, 2 specimens. SAM–H10916, upper Spencer Gulf, Port Germein Bay, 6 metres depth, February 1980, N. Holmes (collector), 1 specimen. SAM–H10919, upper Spencer Gulf near Redcliff, 15 metres depth, 17 November 1980, S.A. Shepherd (collector), 1 specimen. SAM–H 10927, Gulf St Vincent, Adelaide District, Seacliff, 15 metres depth, 12 May 1990, N. Holmes (collector), 4 specimens. SAM–H10925, upper Spencer Gulf, 1.6 km E of Douglas Point (Kinhill Survey Station 3A), 17 metres depth, May 1988, N. Holmers (collector), 1 specimen. SAM–H10928, Kangaroo Island, Penneshaw, 14 metres depth, 3 August 1971, J. Kroezen (collector), 2 specimens. **Western Australia:** WAM–709–91, North Mole, Fremantle Harbour, 25 November 1983, S. Slack Smith/L. Marsh/J. Watson/C. Bryce (collectors), 5 specimens. WAM–707–91B, Albany, Oyster Harbour, ca 6 metres depth, 17 July 1965, E.P. Hodgkin (collector), 1 specimen.

Diagnosis

Maximum length 180 mm. Polyp leaves thin, triangular or semi-circular to kidney-shaped, 22–38 pairs of polyp leaves. Polyp zone of each leaf with autozooids in 1 or 2 rows, at least autozooids 20 per row. Retracted autozooids with single basal tooth composed of converging sclerites. Several mesozooids scattered or in a single longitudinal row on ventral distal extremity of rachis. Peduncular sclerites mostly elongate biscuit-shaped rods, 0.11–0.17 mm long. Colour mostly bicoloured: rachis dark blue-grey or brownish-grey with peduncle cream to orange. Monochromatic orange form less common.

Description

Specimens examined range in length from 60–180 mm. Holotype 108 mm in length while paratype 100 mm long. Length of peduncle constitutes 45–55% of total length of single specimen. Rachis may contain deep longitudinal medial groove along entire length of its dorsal side. 22–38 pairs of polyp leaves, which are thin and variable in shape: from deltoid/fin-shaped to semicircular or kidney-shaped, mostly 8–13 mm in length. Retractile autozooids arranged usually in one or two rows along distal margin of each polyp leaf, with 20–35 autozooids per row. Distal tip of each autozooid has single tooth, which is small, blunt to pointed, and triangular in shape. This polyp tooth projects over top of each retracted autozooid. Siphonozooids densely-crowded on small roughly circular pad, situated on dorsal base of each polyp leaf, adjacent to rachis. Each pad ca 1.7 mm in diameter, and single siphonozooid ca 0.1–0.2 mm in diameter. In addition, 10–28 mesozooids present on distal ventral portion of rachis, usually in single longitudinal row or sometimes randomly scattered. These vary from 0.23–0.50 mm in diameter. All three forms of polyps contain scattered sclerites in polyp walls. Sclerites of polyp leaves and surface of rachis are mostly slender rods and spindles, 0.22–0.93 mm in length. Those of polyp leaves sparsely to densely-set in longitudinal rows between the

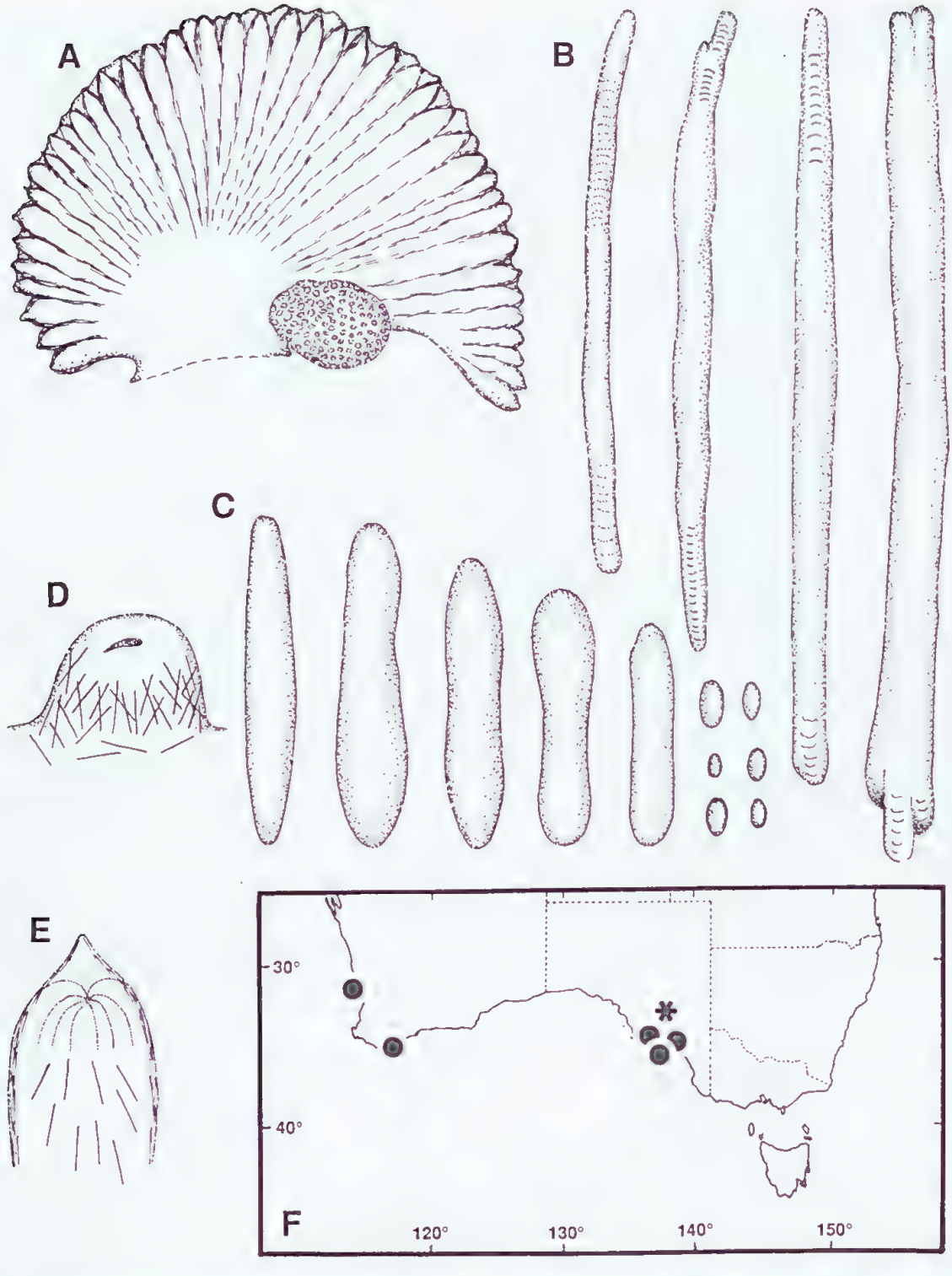

FIGURE 11. *Sarcoptilus shaneparkeri*. **A**, Ventral view of a single polyp leaf (13 mm in length), with siphonozooid pad; **B**, Sclerites of the polyp leaves and rachis, 0.33 mm, 0.48 mm, 0.58 mm, and 0.64 mm in length; **C**, Sclerites of the peduncle, elongate forms are 0.19 mm, 0.18 mm, 0.17 mm, 0.15 mm, and 0.13 mm in length, minute ovals are 0.01–0.02 mm in length; **D**, Lateral view of a single mesozooid, 0.43 mm in length; **E**, Distal portion of a single autozooid, 0.45 mm in width; **F**, Map showing distribution of the species: ✱ = type locality, ● = other localities.

autozooids, as well as being sparsely-scattered obliquely over face of each autozooid just below peristome. Longitudinal rows extend over most of surfaces of both sides of each polyp leaf and radiate outward toward distal margin from base of each leaf. Two adjacent longitudinal rows converge at distal apex of each autozooid to form single inverted V-shaped polyp tooth. Some of sclerites forming tooth blunt and somewhat flattened at distal end. Sclerites from surface of rachis and peduncle arranged mostly longitudinally and in parallel, with a few obliquely

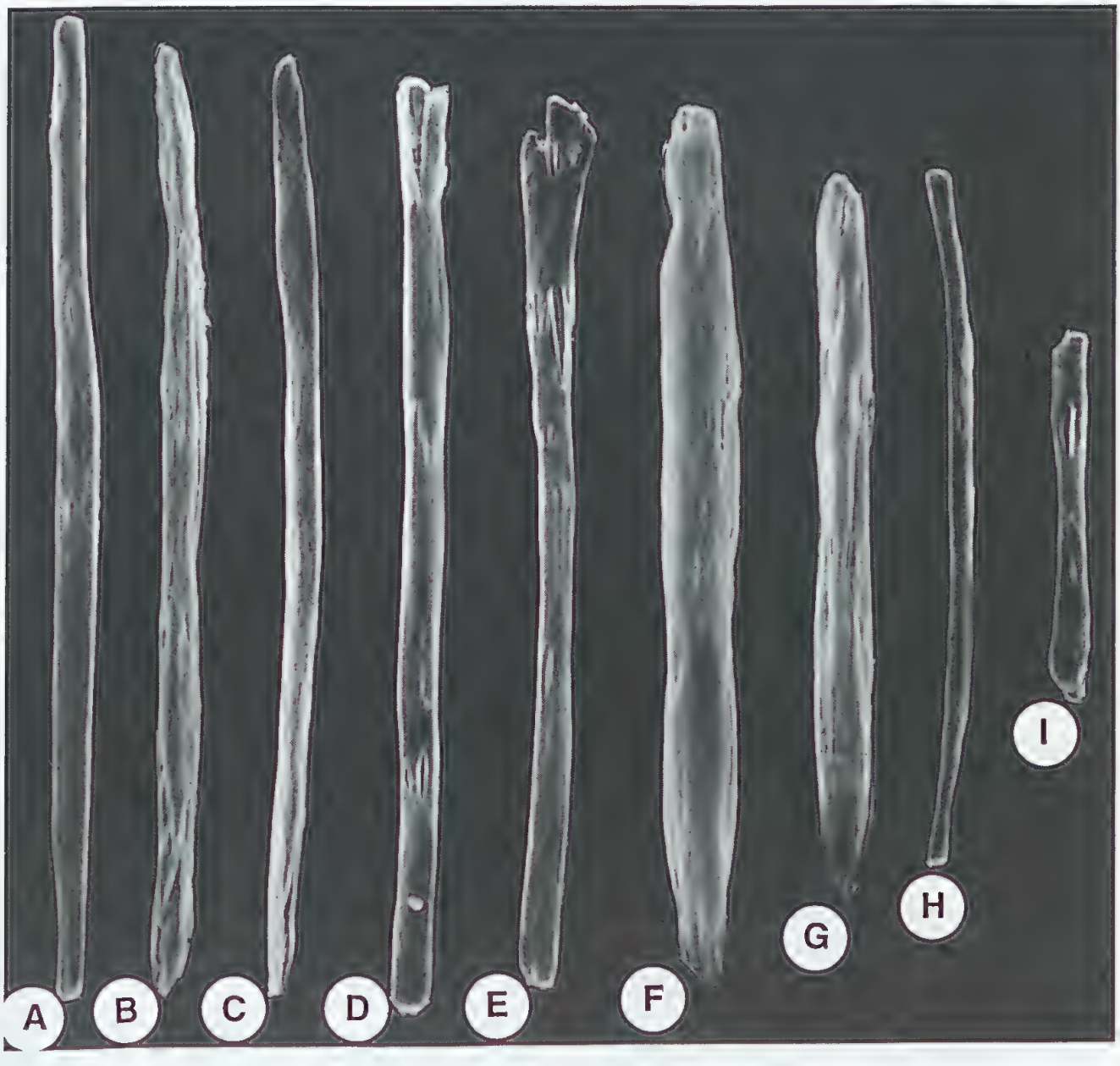

FIGURE 12. *Sarcoptilus shaneparkeri*. Scanning electron micrographs of polyp leaf sclerites. **A**, 0.62 mm; **B**, 0.60 mm; **C**, 0.59 mm; **D**, 0.39 mm; **E**, 0.93 mm; **F**, 0.27 mm; **G**, 0.30 mm; **H**, 0.44 mm; **I**, 0.23 mm.

disposed. Sclerites of surface of peduncle of two distinct kinds—stout smooth rods, sometimes slightly constricted in middle, with rounded ends (0.11–0.17 mm in length and 0.02–0.03 mm in width), and numerous minute ovals (0.01–0.02 mm on length). Sclerites of interior of rachis and peduncle very sparse or apparently lacking. Colour in alcohol of rachis and polyp leaves varies from dark bluish-grey to brownish-grey or violet-grey (rarely orange), contrasting with peduncle which is yellowish-white or pale-orange. Sclerites are colourless.

Etymology

This species is named for Shane A. Parker, late Curator of Lower Invertebrates at the South Australian Museum. Shane originally suggested that the southern Australian pennatulacean fauna be studied. In addition, he supplied on loan much of the essential material for study. Without his interest, enthusiasm, and good humour, this project would not have been possible.

Distribution

Southern Australia (Fremantle Harbour and Albany, Western Australia; Spencer Gulf, Gulf St Vincent, and Kangaroo Island, South Australia); 6–18 metres in depth. This species is apparently locally common in shallow-water of protected embayments, on silty bottom or in hollows of coarse sand between seagrass beds. The type locality is the upper Spencer Gulf, South Australia.

FIGURE 13. *Sarcoptilus shaneparkeri*. Scanning electron micrographs of peduncular sclerites. **A**, 0.15 mm; **B**, 0.15 mm; **C**, 0.10 mm; **D**, 0.14 mm; **E**, 0.13 mm; **F**, 0.14 mm; **G**, 0.12 mm; **H**, 0.12 mm.

Discussion

Utinomi and Shepherd (1982: 208–209) incorrectly identified this species as an undetermined species of *Scytalium*. Members of the genus *Scytalium* have sclerites that are exclusively oval-shaped plates and the siphonozooids are arranged only on the rachis between the polyp leaves. In *Sarcoptilus*, the sclerites are spindles or rods and the siphonozooids are mostly situated on circular pads at the dorsal base of each polyp leaf.

There is a considerable amount of variability observed in this species. Members of the South Australian populations do not exceed 120 mm in length, while those from Western Australia are markedly larger—up to 180 mm in length. The arrangement and amount of spiculation on the polyp leaves varies considerably—from very sparse to very dense. In some specimens, the proximal portion of each polyp leaf is devoid of sclerites. The amount of development of the terminal polyp tooth is also variable—being conspicuous in most members of the South Australian populations, and less strongly developed in others, particularly the specimens from Western Australia. The amount of spiculation present in the surface of the rachis and peduncle is variable—relatively sparse in some to dense in others.

Observations

This species is preyed upon by arminacean nudibranch molluscs (presumably *Armina* sp.) (S. A. Parker, pers. comm.). Many of the specimens observed have the ventral margins of the polyp leaves devoid of polyps—showing signs of being partially eaten.

The following notes on colour, written by S.A. Parker, were found with five specimen lots: (SAM–H10922)—'Colours shortly after collection: stalks bright orange to pale orange, rachis brownish olive to light orange-brown; leaves dark olive-grey-brown; autozooids pale orange to brownish-cream, siphonozooids pale orange'; (SAM–H10923A Holotype and 10923B Paratype)—'Colours shortly after collection: stalk pale apricot-buff, rachis & leaves dull leaden grey with slight brownish tinge; autozooids very pale greyish white to off-white. Siphonozooid pads pale greyish white'; (SAM–H10927)—'Lobes violet-grey, stem creamy-orange'; (SAM–H10928)—'Colour in life: orange'; (SAM–H10925)—'Colours shortly after collection: stalk bright orange, rachis leaves & siphonozooids paler; autozooids whitish orange'. The bicoloured grey/cream form is apparently the most common form and is present throughout the range of the species. The less common monochromatic orange form has only been encountered in upper Spencer Gulf and Kangaroo Island (South Australia) and Albany (Western Australia).

Conclusions

Three species were previously assignable to the pennatulacean genus *Sarcoptilus*: *S. grandis* as the type species, with *Sarcophyllum bollonsi* and *Sarcophyllum roseum* transferable to the genus. This revision adds three new species (*S. nullispiculatus*, *S. rigidus*, and *S. shaneparkeri*), one synonymy (*Sarcophyllum roseum* as a junior synonym of *Sarcoptilus grandis*), and one new combination (*Sarcoptilus bollonsi*), establishing a total of five species for the genus (four valid species in southern Australia and one species of questionable validity in New Zealand (*S. bollonsi*)).

Acknowledgments

I am grateful to Shane Parker, late Curator of Lower Marine Invertebrates at the South Australian Museum in Adelaide, for originally suggesting the study of the southern Australian pennatulacean fauna and for kindly lending the material used in this study.

I thank Loisette Marsh, Curator of Aquatic Invertebrates, Western Australian Museum in Perth, and Dennis Gordon and Paul Anderson of the New Zealand Oceanographic Institute in Wellington for the loan of material from their collections. I also thank Karen Gowlett-Holmes, Wolfgang Zeidler, and Eric Matthews (South Australian Museum) for their cooperation. I am grateful to Darrell Ubick (CAS Scanning Electron Microscope Unit), and Charlotte Fiorito and Caroline Kopp (CAS Photography Department) for their assistance in the production of the plates.

I am indebted to Fred Bavendam, professional freelance photographer, for use of his underwater photograph in Figure 1.

I sincerely thank Marie-José d'Hondt (National Museum of Natural History, Paris) for her helpful ideas concerning the manuscript.

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FOLLOWING THE TRACKS OF EDGAR WAITE IN NEW GUINEA FOR THE PACIFIC ARTS SYMPOSIUM IN ADELAIDE

BARRY CRAIG

CRAIG, B. 1995. Following the tracks of Edgar Waite in New Guinea for the Pacific Arts Symposium in Adelaide. *Records of the South Australian Museum* **28**(1): 33–52.

The Fifth International Symposium of the Pacific Arts Association, held in Adelaide during 1993, provided an opportunity for the South Australian Museum to reforge links with New Guinea and the islands of the Bismarck Archipelago, established through the visit there by Edgar Waite as Museum Director 75 years earlier. This paper describes, in narrative style, the author's experiences during a fieldtrip made to collect relevant artefacts and data and to organise dance performances for the Adelaide Symposium.

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Manuscript received 20 April, 1994.

In 1918, Edgar Waite, the Director of the South Australian Museum, undertook a collecting expedition to New Guinea and the islands of the Bismarck Archipelago (Hale 1956: 115–16). Waite was accompanied by Augustus C. Davis who previously had been a Protector of Natives in New Ireland and was familiar with the area to be covered by the expedition. The former German territory had come under Australian military control following on the declaration of war in 1914, and by 1918 it was only just reopening to other interests. The Bismark Archipelago was not well represented in the Museum's collections and until this opportunity arose, natural history and ethnographic collections would have had to have been purchased through traders such as Richard and Phoebe Parkinson and, even earlier, through 'Queen' Emma and Thomas Farrell, as did the Australian Museum in Sydney (Thomsett 1993: 13).

Waite was first and foremost a naturalist, not an ethnographer (Jones 1992). As was common in the late nineteenth and early twentieth centuries though, museum collectors were generalists when in the field and Waite collected a wide range of natural science specimens and ethnographic material. Although Waite did not stay in any one place long enough to begin to obtain systematic cultural information, he did make many serendipitous observations. In a sense, everything was new and unfamiliar, so everything was worth a comment. His ethnographic data has to be treated with caution nevertheless.

Today the visitor to the Pacific Gallery of the South Australian Museum can see a representative sample of the ethnographic material collected by Waite and Davis, presented in a manner that must differ little from the way it was first displayed in 1919 (see 'New Museum Exhibits', *The Register*, September 13, 1919). The manner of display (Fig. 1) is only a slight improvement on the renaissance 'Cabinets of Curiosities'. The major points of interest are the carved figures and masks made for the series of funerary rituals called *malangan* in New Ireland, and a rare mask from the Sulka people of Wide Bay, East New Britain (Fig. 15).

The South Australian Museum has never had a specialist Curator for its Foreign Ethnology collections. The Pacific collections (including Melanesian material) comprise the largest component of these. Adelaide has arguably the second most significant collection of Pacific material in the country. In 1992, the Anthropology Division of the South Australian Museum offered to host the Fifth International Symposium of the Pacific Arts Association. It seemed to this author that the Symposium could present an opportunity for demonstrating what could be done by the Museum to upgrade its Pacific Gallery and the collections, and data about those collections, on which the Gallery is based.

It was decided that the projects should be joint ventures with the Papua New Guinea National Museum in the case of the Sulka component and with the New Ireland Provincial Government in the case of the New Ireland component. Chris Issac, Acting Director of the J. K. McCarthy Museum in Goroka, a branch of the PNG National Museum, who had been one of my staff when I was Curator at the PNG National Museum, would act as my colleague for the Sulka Project. He himself is Sulka, from the village of Guma on the

FIGURE 1. New Ireland *malangan* collected by Edgar Waite in 1918, on display in the Pacific Gallery of the South Australian Museum (Photo by Trevor Peters, SAM).

south-eastern shore of Wide Bay, East New Britain. In 1982, he was part of the team from the PNG National Museum which collected a magnificent *hemlaut* mask, several *susu* and other masks, and dance wands, clubs and shield from the Sulka. This team consisted of myself, Chris Issac and Rowena Hill[1] who was the Conservator at the PNG National Museum at that time. Chris Issac also worked with George Corbin of the City University of New York in his 'Salvage Art History' project among the Sulka in 1983 (Corbin 1990).

At the South Pacific Festival of Arts held in Cook Islands in 1992, Susan Cochrane[2] had met Noah Lurang, New Ireland Provincial Cultural Officer. She suggested he would be an ideal person to involve in the New Ireland component of the project. He was an experienced high school teacher, was articulate about the *malangan* culture of New Ireland and able to perform masked dances associated with the *malangan* rites.

[1]. Rowena Hill documented the materials used in the construction of the masks and dance wands and later carried out a detailed study of materials and techniques relevant to the masked rituals of the Sulka and Sulkanised Mengen of Wide Bay. This material has been presented as a Masters thesis to the Department of Sociology and Anthropology at the University of Queensland. She has also recorded, and had translated, a corpus of songs relating to the dancing of the masks (see Hill 1982; Craig 1993a).

[2]. Co-ordinator of the Pacific Arts Symposium in Adelaide.

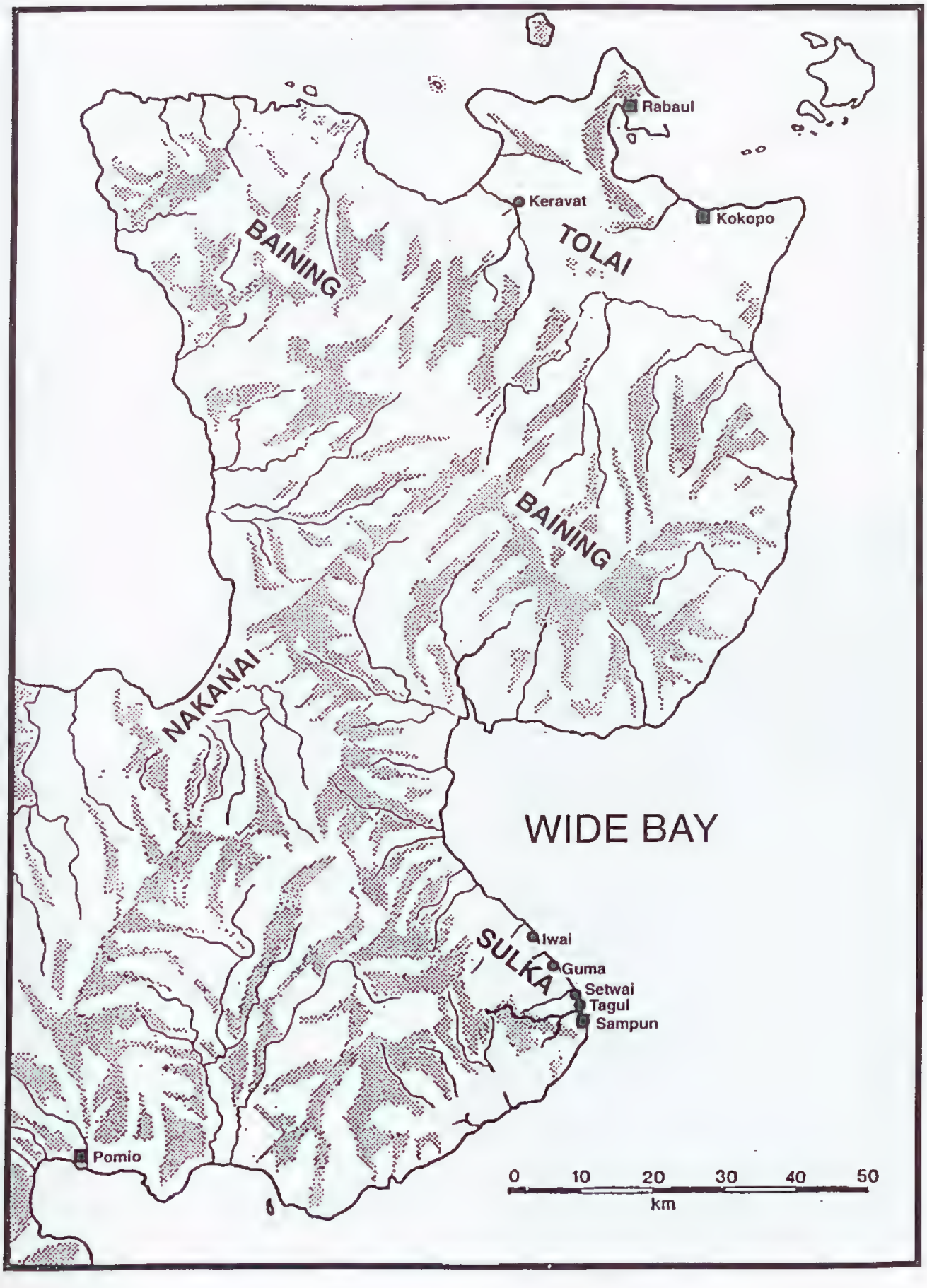

FIGURE 2. Map showing Sulka area, Wide Bay, East New Britain Province, Papua New Guinea.

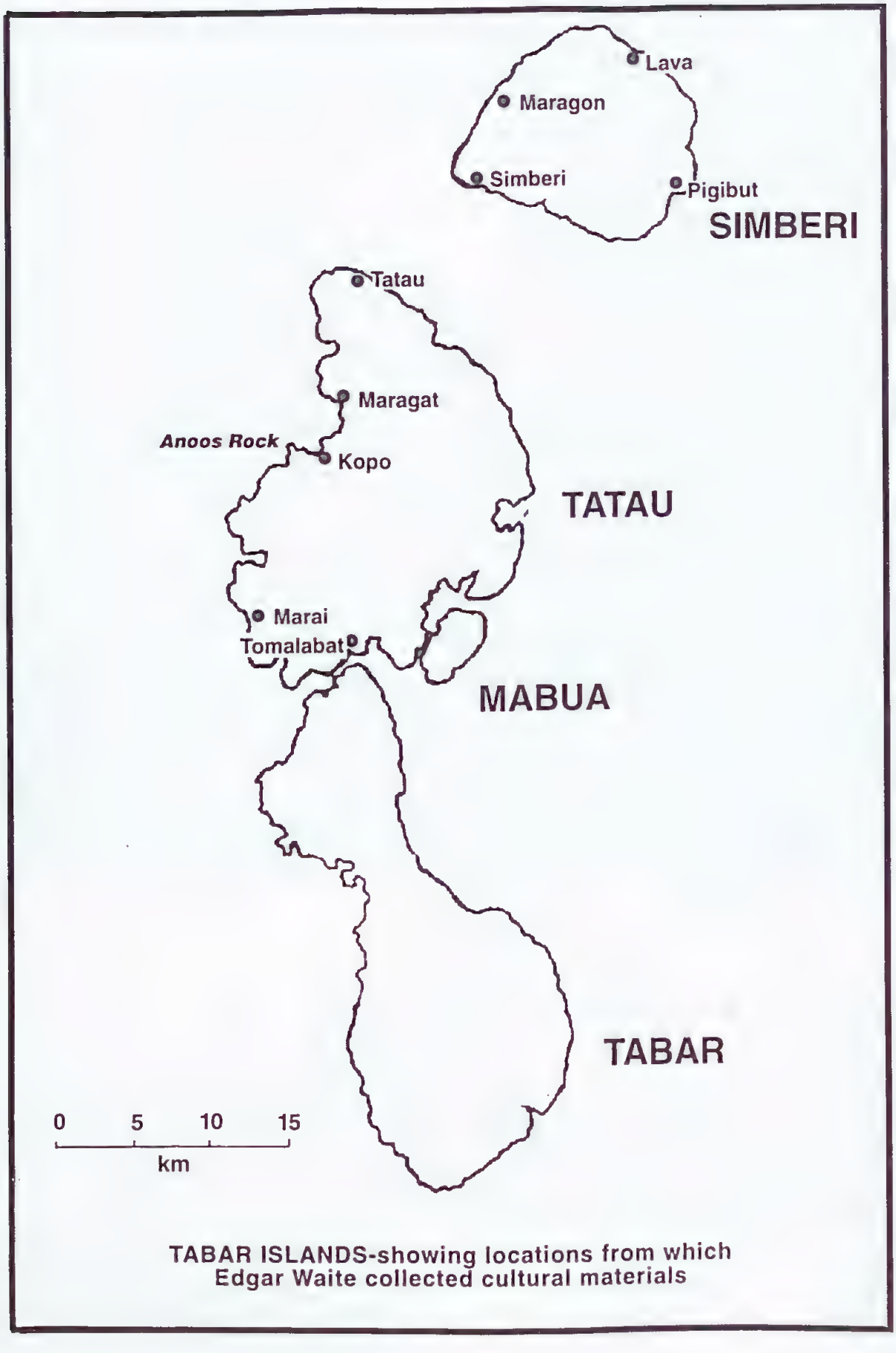

FIGURE 3. Map showing Tabar Islands, New Ireland Province, Papua New Guinea.

At first, it was hoped that funding would be received early enough to commission a copy of the South Australian Museum's rare Sulka *hemlaut* mask, obtained in 1919 and designed to be danced by two men simultaneously. Funding was not confirmed until November 1992, which did not provide sufficient time for a copy to be constructed. However, the performance of mask dancing associated with the initiation of boys and girls is common over the New Year period among the Sulka, allowing an opportunity to record performances and to purchase some of the masks before they were destroyed. It is normal practice to destroy the masks shortly after their performance.

In the case of New Ireland, we proposed to obtain at least two *tantanua* masks,[3] used in *malangan* performances, to place opposite the *tantanua* masks collected by Waite in 1918. *Malangan* performances are rare, but as New Irelanders no longer destroy the *tantanua* masks afterwards, there would be a good chance of being able to buy some.

The fieldwork was not intended merely as a collecting exercise. It was intended to identify two New Irelanders and two Sulka men who would be prepared to travel to Adelaide for the Pacific Arts Symposium and perform the masked dances. The masks would then be set up opposite their much older counterparts in the Pacific Gallery to demonstrate the continuity of these masking traditions and the re-establishment of the relationship between the South Australian Museum and these communities in Papua New Guinea.

A secondary purpose evolved at the last moment. A few days before I was due to depart for Papua New Guinea, I was handed a photocopy of Waite's handwritten journal of his New Guinea expedition. I resolved to follow Waite's footsteps, as much as possible in the short time I had[4], clarifying any obscurities in his journal (Waite 1918) and obtaining photographs and data that related to the locations visited by Waite.

The New Ireland Component

Originally I intended to go to the Sulka area first, and I arranged to arrive in Papua New Guinea in mid-December. In the meantime, Chris Issac established that the people in his village of Guma, on the south-east shore of Wide Bay (Fig.2), were planning masked performances for early January. I therefore changed the itinerary and went first to New Ireland. I had previously informed Noah Lurang that I would be arriving in New Ireland about 7th January and could not get through on the telephone to inform him of the change of plans. When I got to Kavieng, the capital of New Ireland Province, I found that he had taken the opportunity to return to his village on the island of Tatau (one of the Tabar group of islands) over the Christmas–New Year period.

It happened that Waite's main area of activity had been the north-west coast of New Ireland and the Tabar group of islands to the north of New Ireland (Fig. 3). Thus to find Noah I would be following Waite's travels of 75 years earlier. I had the peculiar sensation of simultaneously existing in two streams of time—being with Waite from June to August 1918, and looking for Noah in December 1992.

FIGURE 4. Youth demonstrating use of 'friction drum' (*lunuat*), photographed by Waite on 2nd July 1918 at Lemusmus, south coast of New Ireland.

[3]. For illustrations of this type of mask, see Helfrich 1973: Abb.1–45.

[4]. Six weeks for the whole exercise, including two weeks in New Ireland Province.

The first place I wanted to visit was Lakurafanga. Waite had spent several days at Lakurafanga Plantation, from 27th June till 5th July 1918, as a guest of the manager Mr Ostram, a Finn. With Ostram's place as his base he explored caves nearby to collect bats and narrowly escaped death when he slipped into a small hole in the roof of a deeper cave (Waite 1918: 21–22). My informants suggested that the caves were most likely those they call Ling-saksavak.

Waite walked across New Ireland to Lemusmus on the south-west coast where Mr Hetreich, a sailor and marine artist, had a small plantation. Hetreich gave Waite a friction-drum (*lunuat*) for the collections; these are still being carved and used today and at Kavieng on the way out I was able to purchase one for the Museum. The *lunet* is held between the legs, and the moistened palms of the player's hands are rubbed towards the body over the 'tongues' of the drum to create a shrill vibrating sound. These are played by men only, in connection with funeral rituals, so it is hardly surprising that when Waite tried to get a girl to demonstrate its use for a photograph, she declined (ibid.: 30). He was subsequently able to find a youth who demonstrated its use (Fig. 4).

FIGURE 5. Shark catching equipment held by Sialis of Munun village, Simberi Island, Tabar Group, New Ireland Province. The 'propeller' float is called *kat* and the rattle is called *sorkuoi* (Photo by B. Craig; 27th December 1992).

Back at Lakurafanga, Waite bought shark-catching equipment. This consists of a rope noose with a propeller-shaped float attached (Fig. 5). The shark is 'called' by rattling a rattan ring of coconut shells and the noose is slipped over the shark's head as it surfaces next to the caller's canoe. When the noose tightens and the shark submerges, the propeller is dragged down through the water and exhausts the shark, which is then pulled to the canoe and clubbed to death. A film, 'Shark Callers of Kontu', was made in 1982 by Dennis O'Rourke showing how sharks are caught this way.

During his time in this area, Waite collected, purchased and was given a wide range of material, including birds, insects, reptiles, and a meteorite (gift of Rev. Peekel of the Catholic Mission at Lemakot—ibid.: 25), as well as ethnographic items (Fig. 6). Among the latter were many fine figures and masks associated with *malangan* funeral rituals. So great was his interest in these carvings that he was soon nicknamed 'Masta bilong faiawud' (master belong firewood) (Jones 1992; Craig 1994) because normally the *malangan* carvings were burnt after the rituals were completed.

I had been advised to stay with Lapaseng Meli and his wife Tangalabo at Sali village, located on the Boluminski Highway about sixty kilometres from Kavieng. I explained to my hosts that I was interested in seeing the site of Ostram's house and talking with anyone who might have been there when Waite visited in 1918. Tangalabo brought me to the house of a very old man named Pasa Atunais (Fig. 7), of the village of Lakurafanga. Pasa rose feebly from his bed for the interview; he was about 90 years old and blind now but able to recall that when he was a teenager a white man travelled along Boluminski's road collecting things like snakes, caterpillars, butterflies and artefacts. As it turned out, Pasa was the only person alive today who could recall seeing Waite, although a few others who were infants in 1918 had been told stories of the man's collecting activities.

FIGURE 6. Masks and spears collected and photographed by Waite on 5th July 1918 at Lunapai village, north coast of New Ireland. Most of these items are currently on display in the Pacific Gallery, South Australian Museum.

I was taken to the site of Ostram's house but all that remained were two concrete house stumps and a concrete water tank, bullet-scarred from straffing during the Second World War.

From Lakurafanga, Waite and his assistant Davis sailed to the Tabar Islands on a pinnace owned by Van der Ghynste, manager of Kopo Plantation at Maragat Bay on the island of Tatau. They took ten hours to get there. I travelled by a different route. I took leave of my gracious hosts and continued along the coast to Konos, where I stayed overnight. From Konos, the journey to Tatau Island takes just over two hours by outboard-powered, fibreglass 'banana' boat. The sea between New Ireland and Tabar was relatively calm; there are times when rough seas challenge the nonchalance of the Tabar Islanders and even they prefer to wait for calmer weather.

Van der Ghynste was nicknamed 'Masta Sak-sak' and his pinnace was christened the 'Sak-sak'. Waite reports (ibid.: 22): 'Vanderghinste grows a beard. When the war broke out he said he would not shave until it was over, so they call him sac sac, which means grass (grown on the chin).' In fact, sak-sak means 'sago'. The son of the Simberi Islander who worked on Van der Ghynste's boat supplied another interpretation, explaining that 'Masta Sak-sak was so named because, whenever all other food supplies ran out, he had his labourers go into the bush and prepare sak-sak (sago) to feed himself and the plantation workers.'

Waite and Davis used the Kopo plantation house of Van der Ghynste as a base to explore the islands and add to the already large collections. Waite's journal records: 'Obtained various articles, at different villages, including an old Malagan, estimated to be over 80 years old. For this and a shark float I paid 2 Pounds, for a pig net One Pound' (ibid.: 43).

Upon arrival at the village of Tatau on the north-west corner of Tatau Island, I was taken to the house of Noah Lurang but he had gone off into the bush. Melenga Lembiang attached himself to me and suggested we go look for Noah. Some hours later we met on a mountainside and I was immediately sure that Noah was the perfect choice for Provincial Cultural Officer and would provide a most impressive performance at the Pacific Arts Symposium. Over the next two weeks, we worked together closely and he introduced me to Edward Salle, the best carver in the 'traditional' (early twentieth century) style. These were the two men who would be invited to the conference in Adelaide. I later bought a small figure, called

FIGURE 7. Pasa Atunais of Lakurafanga village, north coast of New Ireland. Pasa remembered collecting insects for Waite as a teenager in 1918 (Photo by B. Craig, 21st December 1992).

walik (Fig. 8), from Edward and it is now on display opposite the old figures collected by Waite.

After a short while, Waite decided to visit Simberi Island, the northern-most of the three major islands of Tabar. Masta Sak-sak took him and Davis across the passage between Simberi and Tatau, the sea so rough that they almost turned back. They landed at Simberi village and walked north along the west coast past Willie Pettersson's plantation to his brother Carl Pettersson's plantation at Maragon Bay. We followed Waite's route and at Simberi village I was shown a *malangatsak* figure with outstretched arms carved by Tames (Thomas) Litir, which I purchased the next day for the South Australian Museum (Fig. 9). We left Simberi and walked north. My guides were able to take me to Willie Pettersson's grave, marked by cordyline plants in a grove of coconuts and wild ginger undergrowth.

Carl Pettersson was known as Charles among the Europeans in New Ireland, as Sali among the Tabar Islanders, and as 'The King of Tabar' in Swedish newspapers (Regius 1993). He had a common law wife named Shindu from Tiripats on the island of Tabar. When Waite arrived, she had just had her sixth child by Sali. Waite

FIGURE 8. Figure called *walik*, carved by Edward Salle of Tatau village, Tatau Island, Tabar Group, New Ireland Province (Photo by B. Craig, 24th December 1992). Purchased for South Australian Museum, Accession number A.74145, and currently on display in the Pacific Gallery of the Museum.

FIGURE 9. Figure called *malangatsak*, carved by Tames (Thomas) Litir of Simberi village, Simberi Island, Tabar Group, New Ireland Province; Tames is at left (Photo by B. Craig, 26th December 1992). Purchased for South Australian Museum, Accession number A.74141, and currently on display in the Pacific Gallery of the Museum.

FIGURE 10. Charles Petterssen, his Tabar Island wife Shindu, and their six children, photographed in Swedish national costume by Waite on 12th July 1918 at Petterssen's plantation, Maragon, on the west coast of Simberi Island, Tabar Group, New Ireland Province.

photographed the family with Pettersson and Shindu in Swedish national dress (Fig. 10). I was able to record brief histories of each of the children and I met Uto, an elderly woman who had been the wife of Sali's third child, Hans (called Anis by the villagers). I was shown the site of Sali's house; nothing but an old gnarled fruit tree remained from those times, everything else being completely obliterated by the Japanese, decay and forest regrowth.

Waite and his host Sali took the opportunity to investigate a turtle-breeding ground on tiny Marwui Island off the west coast of Simberi. They discovered a nest and counted 155 eggs in it. Waite then set out to walk around the northern half of Simberi Island to Pigibut where Meyer, a German plantation manager, lived. Following Waite's trail, we were overtaken by darkness and slept the night at Lava. Next day, at Munun, I met Sialis, one of the last of the shark-callers on Tabar Islands, and photographed the propeller-like float and the coconut shell rattle (Fig. 5).

We walked on to Pigibut and there we saw Meyer's house—the outside walls had been renewed but the concrete stumps, the timber frame and floor were said to be all original. The house had been obtained by Kennecott Mining Company to provide a base for gold exploration and they had added a large kitchen, mess hall, bunkhouses, workshop and separate office to the old building. Although this company had been gone for only a couple of years, the motorbikes, tractors and other vehicles were rusted through, looking as though they had been there for decades.

Waite stayed overnight and reported (ibid.: 59): 'G. M. gave me several things and natives brought others which we purchased. I paid G. Meyer 13 shillings for Bird of Paradise coins: five, two and one mark.' A number of *malangan* carvings on display at the South Australian Museum are labelled 'Pigibut'. Waite was supposed to be picked up at Pigibut by Masta Sak-sak but the seas were too rough. The boat retreated to a safe anchorage at Katatar on the south coast and Waite continued walking, thus circling the island.

Returning to Van der Ghynste's plantation at Kopo on Tatau Island, Waite decided to go by outrigger canoe and on foot to Klett's plantation at Tomalabat, overlooking the narrow passage between Tatau and Tabar to the south. On the way, he collected marine animals among the mangroves and visited 'Anus [Anoos] Rock'.

Anoos Rock is not marked on the maps and I assumed it was a mountain inland from Maragat Bay. However, I was able not only to locate it on the southern tip of Maragat Bay but also recorded the story of an old man named Lome who had been insulted by his wife and went into seclusion on the coral limestone rock in protest. Every day he was seen sitting in the sun on a rock wall he had built and he ignored the pleading of the villagers to return. He refused to eat, wasted away and eventually died. His bones, and the wall he built, are said to remain to this day.

I hired a boat to follow Waite's path along the west coast of Tatau. We called in at Maragat Bay and visited the site of Kopo Plantation but there was no sign that there had ever been a house there. I was taken to Anoos Rock and shown the bones of Lome.

Further south, we came ashore again and slipped and slid along a very muddy track to get to the old site of Marai village on a ridge-top. Waite recorded: 'At a village, Marai, on the summit, I had a "cooler" [juice of the *kulau* or green coconut], the boy climbing the coconut tree without the usual ankle strap' (ibid.: 60). The site now is completely unrecognisable as having been a village. Cement grave markers had been erected there during the late 1970s but were already overgrown.

We returned to our boat and continued south to Tamalabat and I photographed the view south to correspond to a panorama Waite had sketched in his diary. We then left in the late afternoon with insufficient time to return to Tatau village before dark and insufficient fuel. We came ashore five kilometres short of the village and poled the boat in the shallow water inside the reef for two hours to get there.

The night before I was due to return to New Ireland, I arranged to record a series of songs appropriate to the masks to be 'danced' in Adelaide at the Symposium. Dancing a mask without the rhythm of the garamut and the appropriate songs would be an absurdity. After a few trials, with the elderly Joel Pitsia as lead singer, and a master drummer to beat the slit-drum, the group provided an hour of fine singing. They asked me to play the recording back to them to ensure it was satisfactory.

Also a master weaver, Joel Pitsia specialised in constructing the woven *malangan* called *worwora* and in making the various masks called *ngeis* which are not carved but constructed of fibrous materials. I bought three of his small *worwora* and it was agreed that Noah and Edward would bring to the Symposium not only two *tantanua* masks and two carved *wanis* masks (with the intricately-carved 'ear' panels) but also a number

FIGURE 11 a, b. Malangan display structure (*mi-rorou-si-mi-matbu*), with *wowora* disc malangan on right, Tatau village, Tatau Island, Tabar Group, New Ireland Province (Photo by B. Craig, 24th December 1992).

of *ngeis,* to be made by Pitsia.[5] Whereas *tantanua* and *wanis* masks are usually represented in collections of New Ireland material, the *worwora* and *ngeis* are much rarer because they are ephemeral, so I was pleased to be able to add them to the Museum's collections (Fig. 11a, b).

There had been rough weather for a week but during this night the wind dropped, the sky cleared and the voices of the group singing the songs for the masks seemed to bring calm to the sea. Our trip the next morning was uneventful, except that we reached Konos on New Ireland with barely a spoonful of fuel left in the tank. By then I had come to trust the ability of my friends to cope with their environment—not necessarily always to get it right, but to deal with problems with humour and resourcefulness.

They had taken me along the paths trod by Waite 75 years before and provided information that immensely enriched his brief diary entries. It

[5]. For illustrations of these types of masks, see Helfrich 1973: Taf. XII, Abb. 47, 51, 58–64 (*wanis*); Taf. X, Abb. 114–19 (*ngeis*).

was a pleasure in April to show Noah Lurang and Edward Salle first hand the material Waite brought back from these islands and to return their people's hospitality to me. Edward was also able to provide a great deal of information about the carvings Waite had collected.

During the Symposium, Noah presented the South Australian Museum with one of the *wanis* masks (Fig. 12) as a gift from the clan leader, Joel Pitsia; Noah gave two shell rattles and the two slit-drum beaters used during the performance of the *wanis* masks at the Symposium's opening ceremony. The other masks were purchased. From the above account, it is clear what the South Australian Museum got out of the exercise; and those who attended the Symposium benefitted immensely from the performance of the *wanis* and from the explanation of the various types of masks provided by Noah and Edward in a more academic context later in the day. What Noah perceived to be the benefits is best reported by quoting his letter to the South Australian Museum's Director, dated 29th April 1993:

FIGURE 12. Mask (*wanis-si-mi-chur-bangbang*) brought to Adelaide for performance at the Opening Ceremony of the 5th International Pacific Arts Symposium in April 1993. This mask was carved by Edward Salle of Tatau village, Tatau Island, Tabar Group, New Ireland Province. It was presented as a gift to the South Australian Museum by Noah Lurang, New Ireland Provincial Cultural Officer, on behalf of Joel Pitsia, Kuk clan leader, Tauvoi hamlet, Tatau village; Accession number A.74146. It is currently on display in the Pacific Gallery of the Museum (Photo by Trevor Peters, SAM).

FIGURE 13. Sulka *hemlaut* mask, constructed by John Telko and others, being danced at an initiation ceremony, Guma village, Wide Bay, East New Britain Province. Design on underside of 'umbrella' represents a rainbow (*akrei*) (Photo by B. Craig, 9th January 1993).

> It's been a wonderful time we had together over at Adelaide and I wish to express how much I and the other guys have enjoyed the Symposium. The most satisfying thing about this event was the exposure which has broadened our scope on international events and issues, and of course the opportunity for give and take [at the] gatherings. To me, this was a great thing.
>
> Since New Ireland has again made another significant contribution to your collection, especially with the gift of the *wanis* (WANIS-SI-MI-CHUR

BANGBANG) with two bundles of shells strung together as rattles and two short lengths of cane to beat the garamut, I would ask the museum to honour this with respect and favourable consideration in the future. I don't mean that the gift was an investment, no; but that maybe one day the Tatau people may build a small culture house to exhibit their *malangans*; the museum could become invaluable in this way by assisting somehow.

To me the gift was an expression of good co-operation and a better working relationship and of course respect for one another. I hope this understanding will prevail in years to come.

Noah's letter is an expression of the importance of reciprocity. Activities which are expressions of Melanesian reciprocity may appear to be the same as what Westerners call 'investment' but as Noah has pointed out, there are differences. In our culture, an investment is made to obtain a 'return'. Melanesian reciprocity is a cyclical rather than linear phenomenon. It was initiated between the South Australian Museum and New Ireland by Waite but was in hiatus for some 75 years. Noah's hope is that the cycle has been reactivated and will not be allowed to lie dormant again for such a long time.

The Sulka, New Britain Component

I flew from Kavieng to Rabaul to meet Chris Issac and we purchased supplies for our stay in his village. Guma is situated on the southern shores of Wide Bay; the high mountains of southern New Ireland are discernible on a clear day from high ground behind the village. Waite did not visit this area but obtained the spectacular Sulka mask from Major H. Balfour Ogilvy who was an officer of the military administration in New Britain (Gash & Whittaker 1975: Plate 392).

The normal means for getting to Wide Bay and points further south on the east coast of New Britain is by small diesel-powered tugs which function as passenger ferries, carry supplies in to villages, missions and administrative centres, and carry out copra and cacao.

The Sulka, and their culturally alike (but linguisticly distinct) Mengen neighbours to the south-east, are gardeners inhabiting a narrow coastal fringe, fishing from small outrigger canoes, hunting in the hinterland and raising pigs for ceremonies such as those for which the *hemlaut* and *susu* masks are danced. They obtain

FIGURE 14. Sulka *hemlaut* mask, under construction by John Telko and others, for an initiation ceremony at Guma village, Wide Bay, East New Britain Province. Design on underside of 'umbrella' represents tips of fern leaves (*priau*) (Photo by B. Craig, 7th January 1993). This mask was purchased for the South Australian Museum (Accession number A.74139) and was danced by John Telko at the Opening Ceremony of the 5th International Pacific Arts Symposium in April 1993. It is currently on display in the Pacific Gallery of the Museum.

some cash by harvesting copra and cacao from their many small plantations. A variety of trees produce nuts and fruits in abundance and the chewing of betel nut is universal—more common than smoking tobacco. Life is so pleasant in the villages that the older men have to exert considerable pressure to get the young men to go to Rabaul to do occasional business.

The trip takes about 10 hours to Guma and we arrived after dark. We were put ashore in a three-metre dinghy and Chris's family made us welcome. The next day we were taken to a hut a few hundred metres up behind the village where a dozen young men were preparing two *hemlaut* masks for performance in a couple of days' time. I photographed the completion of one of the masks, which involved the delicate sewing of strips of flattened pith to a rattan armature, and the painting of the designs on the conical headpiece and underside of the 'umbrella' form on top of the masks. One of the designs, parallel bands of colours spiralling towards the centre of the 'umbrella', is named *akrei* (rainbow); the other is named *priau* (tip of fern leaf) (Figs. 13, 14). I later discovered the name of the design on the *hemlaut* in the South Australian Museum (Fig. 15): *a hevotek kalogu* (claws of a freshwater cray). These interpretations are visual metaphors and may be connected to clan totems but only a long-term study would be likely to elucidate their full cultural significance.

I realised I was going to have considerable difficulty deciding which mask I would choose for the performance in Adelaide—one was sculpturally more interesting but the other had a more interesting design on the underside of its 'umbrella'. I was also concerned about how to select the two men who would be invited to come to Adelaide to dance the mask. It was a relief to learn that the mask and the men had already been chosen, on the basis of messages between Chris and me and between Chris and his relatives in the village. This clearly indicated that the project had the understanding and enthusiastic support of the men of the village. Similarly, the price asked for the mask was kept at a modest amount, meant to compensate those men who had assisted to make the mask but who had not been chosen to go to Adelaide.

There was to be an afternoon performance of mask dancing at the village of Tagul, two hours walk south-east along the coast from Guma. We set out early in the afternoon, the sounds of the sea on our left and of the wind in the coconuts on our right. As we approached the village of Tagul through a tunnel of trees, we could hear the drumming and singing that accompanies the performance of the *hemlaut* masks. We crossed a creek, ascended sharply and there, coming toward us from the large crowd gathered at the centre of the village, was the first of three *hemlaut* being danced that day: an apparently gigantic figure shrouded in green palm leaves wearing a red conical structure supporting a two-metre diameter 'umbrella' painted on the underside with curving flower-like forms.

I followed the *hemlaut* into the preparation area behind the village and ran into a line of eleven *susu* masks getting ready to make their appearance. A senior initiate rushed to head off the maskers and berated them soundly for failing

FIGURE 15. Sulka *hemlaut* mask of a rare type called *lopela*, designed to be danced by two men simultaneously. This mask was obtained by Waite in 1919 from Major H. Balfour Ogilvy, whom he had met on his New Guinea Expedition in 1918. This mask (Accession number A.7416) has been on display in the Pacific Gallery of the South Australian Museum for several decades. The design on the underside of the 'umbrella' represents claws of a freshwater crayfish (*hevotek kalogu*). Exact provenance, and photographer, are not known.

to await their cue. His abuse in Mengen, assuring an uncomfortable reward for a premature performance, was punctuated with the English emphatic: 'Honest to God!' In due course they were given a signal and the masks moved in solemn procession into the village (Fig. 16), their shiny green palm-leaf body-shrouds swaying in unison to the drumming of a group of singing women.

The ceremonies in which *hemlaut* and *susu* are danced are primarily for the initiation of boys and girls, the boys being circumcised and the girls having their noses pierced. The school holidays over Christmas–New Year are therefore the period in which the masks are most likely to be danced.

They are danced also for funerals, marriages and other special events. In 1982 I witnessed the induction of a Sulka man, Joe Quintaip, into the Franciscan priesthood. This ceremony commenced as a Catholic service presided over by the Archbishop of Rabaul and ended with traditional masked dances which included a *hemlaut* performance. The masked performances were doubly appropriate as Joe Quintaip's ordination was considered by his relatives as both an initiation and a death—initiation into the knowledge and rituals of the Church and a death to normal village life.

The *hemlaut* for that occasion was designed to illustrate a Christian story and since the ceremony was conducted soon after Christmas, the theme chosen was Bethlehem. Accordingly, beneath the two metre diameter umbrella-like form characteristic of the *hemlaut* mask, an elaborate woven sculpture was created representing Mary, Joseph and two angels kneeling around the baby Jesus lying in a manger.

At Tagul, on this trip in 1993, I was most fortunate to observe another complex *hemlaut* mask, this time with a traditional Sulka story represented beneath the 'umbrella' (Fig. 17). This was the story of the two brothers named Noot, a younger brother who lived in the hills and an older brother who lived by the sea:

> The younger brother was always coming to the older brother's place and seducing the women. This made the older brother so angry that he captured a lot of men of his own village and tied them by hands and feet to poles and contemplated cooking and eating them. But it didn't look right so he released the men and instructed them to bring pigs to take their place. They had a big feast but this attracted the younger

FIGURE 16. Procession of Sulka *susu* masks, Tagul village, Wide Bay, East New Britain Province (Photo by B. Craig, 7th January 1993). Two of these masks were purchased for the South Australian Museum (Accession numbers A.74135, 74136) and are currently on display in the Pacific Gallery of the Museum.

FIGURE 17. Sulkanised Mengen *hemlaut* mask being danced at Tagul village, Wide Bay, East New Britain Province (Photo by B. Craig, 7th January 1993). This mask has a woven sculpture beneath the 'umbrella', representing the legend of two ancestral brothers named Noot.

> brother again and this time he seduced the older brother's wife. The older brother began to plot his younger brother's death. He commenced the building of a men's house which required a very deep hole for a carved and painted centrepost and lured his younger brother into the hole, then dropped the post into it, but the younger brother escaped by following his dog, which had dug a tunnel out of there. Then the older brother held a feast and invited the younger brother, intending to kill him with a wooden club but the younger brother sent an animated wooden likeness of himself and again escaped death.
> The two brothers then fought with slings and fire and the younger brother took the older brother's wife and flew away, some say in an aeroplane to a great land in the south, to become the ancestor of the white people (B. Craig ms.).

The mask I saw danced at Tagul consisted of a central figure representing the older brother Noot holding up the 'umbrella', surrounded by a representation of a man trussed up on a pole with a trussed pig opposite, and an oval men's house, with a tall food storage bin in front, opposite the younger brother's dog.

The structure of the 'Bethlehem' and 'Noot' masks were the same: a central figure surrounded by four significant elements of the story. The other *hemlaut* masks danced at Tagul that day also exhibited this four-part structure, though the sculptural elements were simpler petal-like forms or merely suggested by the design on the underside of the 'umbrella'[6]. But there is more to these masking traditions than their forms: for example, the songs that accompany their display and performance. Rowena Hill, Conservator at the PNG National Museum in 1982, recorded several and had them translated (Hill 1982: 98–107). This is a song to accompany a *hemlaut* mask:

> A woman gave birth to a snake; her husband took her to a magic reef where there lived a spirit called *kot*. When the snake came out from her belly his tongue was red and forked and [he] covered the

[6]. I was struck by the similarity of these designs to those of mandalas when, in September 1994, the South Australian Museum hosted a group of Tibetan Buddhist monks who demonstrated the 'sand-painting' of a *Mandala for Peace*. They set up their space immediately in front of the old Sulka *hemlaut* mask in the Pacific Gallery but missed the opportunity to allow onlookers to draw the comparisons by covering up the case in which the Sulka mask was displayed.

whole woman, wrapping himself around her like the underneath of the 'umbrella' mask.

A song to accompany the dancing of the *susu* masks:

> A man was standing on top of a hill overlooking a village called Indaru when he heard an echo, bouncing from a cliff, of a woman singing. Out of the waterfall came her two sons; they were as beautiful as a pair of cockatoos.
> They were sitting on top of the cliff, one on each side of the waterfall. The man saw them both and as he fixed his gaze they merged into the white flowing waterfall and kept flowing and flowing.
> The *susu* mask is dancing like a flower blowing in the wind. Its skirt like leaves is swinging to and fro. The mask is like the flower dancing on the stem.

One song which seems to be concerned with the pan-human problem of communication between men and women laments:

> A woman was standing on top of a hill, and on her face she wore a mask of [white] lime and plant juice. When I tried to talk to her she refused to speak and stood there facing the setting sun. When I approached her she started to cry; I felt sorry for her and started to cry in sympathy. Suddenly she disappeared and I did not know what to do or say.

The rather magisterial and fearsome appearance of the masks is belied by the sensitivity and imagery of many of these songs.

After arranging to purchase two of the *susu* masks for the South Australian Museum, and for the 'Noot' mask to be put aside for consideration by the PNG National Museum (the masks are normally destroyed soon after performance), we commenced our walk back to Guma. I fell into step with the Provincial Minister for Education, who is Sulka, and he assured me that the Provincial Government is fully supportive of such projects as the one we were engaged upon, providing that there is full agreement among the villagers and that the PNG National Museum is supportive.

It rained heavily next morning and this prompted the information that someone can be commissioned to cause rain in order to spoil a feast. Rain can be induced by placing stones, carved as human heads, in a river and stopped by taking them out. Another method is to saturate a knotted rope with the juices of a particular plant and then to spray the juices around by whirling the rope vigorously; the spell is cancelled by undoing the knots in the rope. The fear of rain being brought on to spoil a feast is also common among the New Irelanders.

That afternoon Chris and I went to the bush shelter where the masks were being made for the performance in Guma village. I continued photographing the painting of the masks, and the preparation of two masks called *keipa*. The *keipa* mask is a simple cap of woven vine or rattan with eyes painted on it and the usual body-covering of palm leaves. They are sometimes referred to as 'whipping masks', as the wearers burst in while the women are dancing during the first afternoon of the festivities and lash those who are to receive the food piled up in the middle of the village for distribution. These masks are also used to ensure a prompt supply of food to the young men who are constructing and preparing the masks in the bush shelter.

I was invited to offer myself as a recipient of the attentions of the *keipa* masks that afternoon but managed to convince my hosts that I needed to make good use of my cameras during the event. Sometimes the notion of 'participant observation' becomes distinctly uncomfortable!

After the whipping episode, the women returned to their singing and in due course a man stood in front of the heaps of tubers and pork and called one-by-one the names of the recipients of the food. Within a half hour the space had been cleared and the food distributed to individual households.

At midnight I recorded an hour and a half of singing and dancing. The men were clustered around a painted sapling, something like the European maypole, drumming and singing, with a line of women circling them clockwise. Off to one side a line of women and girls in traditional dress sang separate songs. There were quite lengthy pauses in the singing with some experimental drumming and voice-testing as catalysts for what appeared to be an impromptu selection of songs from a widely known corpus. Chris told me that some of the songs are in a very old language that few people, if any, understand; that other songs are metaphoric or contain oblique references to the real meanings; and that others can be made up on the spot—an opportunity for creativity. The singing and dancing continued until dawn.

Next day the *hemlaut* masks were completed and the palm-leaf body shrouds attached. The shroud is in two parts—one attached to the lower rim of the mask itself on a rigid frame and the other on a flexible frame is worn by the dancer suspended from shoulder straps. This enables the mask to undergo amazing transformations in size. When the masker crouches, the shroud diminishes, concertina fashion, to about a metre in height and the mask appears to be short and fat; when the masker leaps into the air, the shroud extends fully

two metres in height and the mask appears gigantic. West African maskers use the same device to achieve identical effects.

The introductory women's songs, to call the masks, began about 3.30pm and, shortly after, the first of the *hemlaut* masks was led into the village by a crowd of singing men. When the mask reached the men's house at the other end of the village where a young lad awaited circumcision, the group of singing men stood back from the *hemlaut* and allowed it to perform in a clear space while they continued drumming and singing; then it left—all over in about ten minutes. There was a hiatus and eventually the women's group recommenced singing and drumming, calling the second *hemlaut*. It was led in by the men and when the space was cleared for its solo performance, the mask was danced in sequences where it was tilted 90° to the vertical to allow a clear view of the design on the underside of the 'umbrella'—a standard procedure during performance. The crowd applauded the performance. Then the two little girls who were undergoing initiation were publicly presented, followed by the circumcision of the lad in the men's house. The *hemlaut* continued dancing around the men's house and the men crowded around whistling, yelling and singing, and banging on the corrugated iron covering part of the roof of the house so that the whole house shook, to drown out the cries of fear and pain from the boy. Men were drumming vigorously inside the house as well. At about five o'clock in the afternoon, dishes of cooked food were brought and placed in palm leaves in front of the men's house and a squealing pig was secured to a pole and carried off. The second *hemlaut* departed from the village only to reappear later and attempt to intimidate a crowd of children. Cooked pork was distributed amongst the cooked tubers and then women came with their dishes to collect their portions.

That evening Chris relayed several criticisms of the *hemlaut* performances. The first masker was inexperienced and failed to 'show the writing', ie. the underside of the 'umbrella', adequately. The second masker was much better but made a mistake by leaping up into the air during the second song when he shouldn't have. Apparently everybody laughed at that; I had heard them laughing but thought it was excitement.

In general, it was felt that the whole thing was too rushed and should have taken place over four, rather than two, days. The first day—when the *keipa* masks whip the receivers of food—is called *elaton*. The second stage, called *mselor*, should take place three months later, to allow time to get all the food ready; this requires the women to perform their songs whilst the food is set out in heaps for distribution. The third stage, *elonpik*, should occur the next day; the women perform again and the food is distributed to those invited to the feast; the initiated men are invited to eat in the bush shelter where the masks are being prepared. On the final day, *kamit*, the masks are danced as described above.

According to pre-colonial traditions, everybody went through three stages of initiation. For males this involved circumcision as boys, then the wearing of the masks as youths, and finally teeth-blackening (rarely performed these days). Girls may have their ears and noses pierced at their first initiation, but I was unable to discover what actions, if any, were performed at the second stage (which I assumed was first menses) and at the third, which was when they were of marriagable age[7]. The feast for circumcision and nose-piercing is called *pam-o-wlongtuk*.

On the evening of the eighth day of my stay at Guma, the boat arrived to take us and the masks to Rabaul. When darkness fell, the *hemlaut* was brought down to the beach and taken out to the boat in the dinghy. The smaller masks had been packed in cardboard boxes. The boat's crew had ensured there were no women or children on board and we lowered the canvas awnings around the deck to protect the *hemlaut* from sea spray and to ensure the mask would not be seen by women and children when we arrived in Rabaul in the morning. Women and children are expected to regard the masks as spirits, not as manufactured items worn by men, which is why they are normally destroyed after their performance.

We departed at 7.15 pm and the journey was uneventful. We arrived at 5.15 am and had to wait a couple of hours before the wharf was clear of women and children and we could safely transfer the *hemlaut* to a lock-up shed. I spent the rest of the day and part of the next buying materials for a large plywood crate, building the crate, securing the masks inside and having it trucked out to Airniugini's cargo shed at the airport to await the Dash-7 cargo plane scheduled for Tuesday. Chris and I flew to Port Moresby on Sunday, passing over an active volcano on the western side of New Britain. The volcanoes around Rabaul, which were to erupt in spectacular fashion during 1994, were quiescent.

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7. Such matters are not likely to be told to a male enquirer.

On Monday morning I received a call from Rabaul saying the crate was too large for the plane. Even though I had built it within the dimensions provided by Airniugini staff in Rabaul, they had forgotten the requirement for walk space from the front of the plane to the rear. I had to get back on a plane for Rabaul that afternoon to take the crate apart and remove the masks, which I then completely covered in yellow plastic to disguise their nature. Next morning I supervised the loading of the disassembled crate and the masks, ensuring there was walkspace through the cargo hold. On arrival in Moresby, we unloaded the masks and crate into a hired truck and transferred them to the PNG National Museum where I arranged for fumigation and space to reassemble the crate and repack the masks.

Discussion

Airniugini sponsored the airfares of myself, Chris Issac, the four New Guinea dancers and the airfreight of the collection through to Sydney, thus saving a considerable amount of expense. Even so, the non-salary field expenses for the six-week trip amounted to around $6 000 and freight from Sydney to Adelaide, internal airfares and accomodation for the four dancers, the purchase of additional masks brought to the Symposium by the New Ireland dancers, and the installation of the material in the Pacific Gallery added about another $5 000. Nevertheless, for the $11 000 spent, Symposium delegates were treated to two magnificent demonstrations of masked performances, the cultural significance of the masks were explained by indigenous spokespersons and a radical upgrade of two small sections of the Pacific Gallery became possible. The objects, photographs and information obtained in New Ireland and New Britain constitute a major additional resource linked to existing collections of objects, photographs and written material held by the Museum. The possibility of collaborative exercises involving Anthropology and Natural History researchers is also indicated, especially in relation to the ethnographic and natural history specimens collected by Waite in New Ireland and Tabar Islands.

One unforeseen outcome was the generation of a debate about the motivations, ideology and ethics of the whole exercise, including the Pacific Arts Symposium itself (Chance & Zepplin 1993; Zepplin 1993; Craig 1993b; Fergie 1994). For example, Zepplin writes accusingly that:

> Cultural objects and customs of the Pacific remain appropriated within the intrepid, pith-helmeted domains of anthropology, archaeology and natural history museums (read: exotic, alien and boringly impenetrable)—the authorised exposition of the Other (1993: 15).

Although it is not apparent to the visitor in the Pacific Gallery, the South Australian Museum is committed to a program of consultation and involvement of indigenous people with the cultural material held in this institution. This has been the major strategy in relation to Australian Aboriginal material for at least a decade now. The exercise I have described is one model for what might be done in relation to the non-Aboriginal cultural material. The stimulation of debate about the success and propriety of the outcomes of the opportunistic exercise I have described need not be read as a threat, but rather as an indication that we are moving in the direction of relevance to contemporary concerns and have not run aground in the shoals of nineteenth century attitudes and values.

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'A SPECIAL INDUCEMENT': THE ESTABLISHMENT OF THE *RECORDS OF THE SOUTH AUSTRALIAN MUSEUM.*

PHILIP JONES

JONES, P. G. 1995. 'A special inducement': the establishment of the *Records of the South Australian Museum*. *Records of the South Australian Museum* **28**(1): 53–59.

The first edition of the *Records of the South Australian Museum* was published on 24 May, 1918. While the journal has been published continuously for seventy-six years, the South Australian Museum was nevertheless one of the last major Australian museums to launch its own scientific journal. The delay was not due to any dilatoriness on the part of its staff in producing scientific papers; it reflects instead the enduring success of the colony's first scientific journal, the *Transactions of the Royal Society of South Australia*. The crucial role of Edgar Waite in the establishment of the *Records* is documented in this paper.

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Histories of colonial museums have generally overlooked the role of scientific journals in marking the transition to what Bassala has described as 'the final phase of a struggle to attain an independent scientific tradition' (quoted in Moyal 1976: 4). These journals were crucial for the professional legitimation of colonial science. In Britain and Europe, scientific journals had evolved from the reports produced of their meetings by the academies, which had in turn arisen from the Renaissance universities. In colonial Australia, this long process was compressed into little more than twenty or thirty years. Adelaide's Philosophical Society for example, was formed in 1853, just seventeen years after the colony's foundation. It played a major part in the foundation of the South Australian Museum, and reconstituted as the Royal Society of South Australia, produced the colony's first scientific journal, the *Transactions of the Royal Society*, in 1878. This pattern was mirrored in the other Australian colonies (Inkster & Todd 1986: 111).

In their attempts to represent the gamut of scientific endeavour, the journals of the scientific academies and museums defied a trend towards greater specialisation which had accompanied the rapid increase in the volume of scientific journals during the nineteenth century (Thornton & Tully 1971: 277–93). To a large degree, museum journals have retained this eclectic character today.

Apart from Adelaide, the major Australian museums of Sydney, Melbourne and Brisbane had all founded their museum journals by the turn of the century. The *Records of the South Australian Museum* celebrated seventy-five years of continuous publication in 1994, but while it is one of the longest running museum journals, it was founded considerably later than its sister publications. The delay does not imply a relative scientific immaturity or lack of independence in Adelaide; cultural dependence upon Britain was at least as high in other capitals. The historian of science Ian Inkster has argued that:

> Australian scientists remained peripheral to the cultures of both the mother country and the colony. They were spatially distant from Britain, but mentally isolated from the provincial centres in which they lived and worked (quoted in Sheets-Pyenson 1988: 14).

Adelaide was among the first Australian centres to focus upon the issues of building indigenous collections and regulating the unimpeded flow of natural history and ethnographic specimens out of the country (Kohlstedt 1984a; 1984b). Together with the Canterbury Museum, the South Australian Museum was also one of the first in Australasia to establish an international reputation for particular indigenous collections, notably ethnology and palaeontology (Sheets-Pyenson 1988: 100).

The relatively late foundation of the South Australian Museum's *Records* can be attributed to the very close relationship which its scientists, and those of the University of Adelaide, had with the Royal Society of South Australia. The Society's office holders were drawn principally from the Museum and the University during the decades of the 1880s, 1890s and 1900s, the years in which an independent museum publication

might otherwise have arisen. The network of Adelaide's scientific and cultural institutions and individuals was extremely tight, both physically and socially. The proximity of the main institutions and their libraries on North Terrace fostered the growth of overlapping and complementary scientific relationships. The South Australian Museum's role, particularly in the fields of zoology and ethnology, was that of a 'keystone' institution, at least until the establishment of the University's Chair of Zoology (1922), the Department of Entomology at the Waite Institute (1927) and the Division of Animal Nutrition, CSIRO (1929) (Edmonds 1986: 207). Moreover, the siting of Adelaide's Museum, Library, Art Gallery, and University on the one city block was unparalleled elsewhere in the country. Inkster's model of 'mental isolation' does not seem suited to turn-of-the-century Adelaide.

The Museum's Director from the 1880s to the First World War was Professor Edward Stirling, himself a founder of the University of Adelaide Medical School and a Royal Society office holder. His own prestigious award as a Fellow of the Royal Society in London was made principally because of his publications on Australian zoology and palaeontology which appeared in the Society's *Transactions*. Stirling considered that the journal was more than adequate to serve the needs of his staff and the colony during this period. Stirling's University colleague and fellow Museum Committee member, the geologist and zoologist Professor Ralph Tate, used the *Transactions* as his forum to remind readers of Adelaide's capacity as an independent centre of research. The British Museum itself, he stated, 'owes to us some of its knowledge of the natural history of the colonies' (Tate 1878).

Tate made these remarks in the 1878 inaugural edition of the *Transactions*, for which he appears to have been largely responsible. Tate played a large role in reinvigorating natural science in South Australia at this time:

> From his arrival in 1876 Ralph Tate, professor of natural science at the new university, the whole status of the Adelaide [Philosophical] society was changed, new rules were drawn up, and publication was put on a sound and permanent basis by the foundation of a regular journal. Scientific contributions came in abundantly for the first time and soon exchanges were arranged with societies around the world (Inkster & Todd 1988: 114).

For the following forty years the Royal Society's journal remained the principal outlet for scientific publications in South Australia. Through a period in which the Museum was only beginning to establish its collections and its scientific expertise, the Royal Society, like others around the country,

> provided a nucleus around which young scientific communities could grow and mature. They had attracted a broad-based audience for science and had established comunication links within and beyond Australia (Inkster & Todd 1988: 115).

In the meantime, the early years of the *Transactions* were uncertain. The journal relied upon the subscription of members with a matching government grant and for several years it was published irregularly. This fact prompted the Museum's Director of the early 1880s, Wilhelm Haacke, to consider the publication of a scientific journal under the auspices of the Museum itself. The proposed journal would:

> contain notices of new species of the Australian fauna, anatomical monographs thereof, and notices of new modes of mounting and preserving specimens and apparatus thereof.[1]

Haacke, who had been appointed to his post from the State Museum of Jena in Germany, went so far as to propose a publisher—the firm of N. Engelmann of Leipzig, Germany. The South Australian Museum Committee instructed him to make further enquiries as to the costs of printing and publishing a journal, but by November 1884 Haacke had resigned and no further action was taken. That year also saw the Museum's official amalgamation with the Public Library and the Art Gallery under a new Act; this factor alone would have lowered the chances of a new, independent museum publication being developed.

The *Transactions* provided a convenient and prestigious outlet for the publications of Museum staff. Edward Stirling led the way as the Museum's Director, maintaining an active publication record in the *Transactions* and encouraging its use by other natural scientists and ethnologists. During 1909 Stirling received a request from the Perth Museum for a South Australian Museum publication and he placed the matter before his Committee for consideration. Their conclusion was that any independent publication by the Museum staff would 'seriously affect' the Royal Society.[2] This consideration influenced any discussion concerning a scientific journal for the following eight years.

The catalyst for a renewed debate was the retirement of Edward Stirling from the directorate

1. Minutes of the Museum Committee, 9 January, 1883. GRG19/364/1883, p.119, State Records Office, Adelaide.
2. Minutes of the Museum Committee, 8 September, 1909. GRG19/364/1909, p.181, State Records Office, Adelaide.

FIGURE 1. Edgar Ravenswood Waite, Museum Director 1914–1928, who was successful in convincing the Museum Committee to recommend to the Board that the Museum should issue its own scientific journal.

at the end of 1912 after thirty-one years of service, and his replacement during April 1914 by Edgar Waite (Fig. 1), previously Director of the Canterbury Museum (Jones 1992).

Waite brought with him considerable experience as an editor and contributor to scientific publications. During his early career as Curator of the Leeds Museum in England he had edited the Museum's journal *The Naturalist*. He had been an active contributor to the Australian Museum's *Records* while Assistant Curator of Zoology, and had gone on to found and edit the *Records of the Canterbury Museum* in 1907. Waite was conscious that the South Australian Museum lagged behind other states in not publishing a journal, but the *Transactions* continued to serve his staff well. In fact, the average length of each issue of the *Transactions* steadily increased during the period after 1910: 257 pages in 1911, 273 in 1912, 496 in 1913, 528 in 1914 and 892 in 1915. This in itself helped to focus the debate on the need for an independent museum journal.

Waite first raised the issue of a scientific journal for the consideration of the Museum Committee in his Director's Report of 1 November 1916. A Sub-Committee was established to examine his proposal and immediately encountered a familiar obstacle. The main concern was that there had been 'a long standing idea that the Museum Officers are compelled to supply original matter for publication to the Royal Society of South Australia only'.[3] Unable to find any evidence of any formal obligation of Museum staff to publish in the *Transactions*, the Chairman of the Public Library, Museum and Art Gallery Board asked the Royal Society for clarification. The Society's Secretary, W. P. Gill, confirmed that no formal obligation existed.[4]

This obstacle overcome, Waite was in a position to advance the argument. He did so in a lengthy formal proposal to the Board, dated 10 January, 1917:

> The covert suggestion previously made and now definitely formulated is that the S.A. Museum issue a scientific publication to be devoted to the research work of the staff, including records of the expeditions, descriptions and illustration of objects in the Museum, occasional notes and the work of outside investigators dealing with Museum material. The publication to be edited by the Museum Director, to be issued at no stated intervals, but when material to form a part is available, a suitable number of such parts to form a volume.[5]

Waite stressed the benefits of an independent scientific publication devoted to the Museum, noting that an alternative suggestion had been made for the launch of a publication representing 'all the ramifications' of the composite institution, the Public Library, Museum and Art Gallery.[6] He advanced five main arguments for an independent publication. It would firstly relieve the pressure on the *Transactions* which was forced to publish unreasonably large volumes. It would enable the Museum Library to benefit from receiving publications in exchange from other scientific institutions. These publications would be 'precisely the kind of literature required for Museum use'. Thirdly, in Waite's view a scientific

3. J. R. G. Adams to W. J. Sowden, 6 December, 1916. Docket no.103/1917/3737, State Records Office, Adelaide.

4. J. R. G. Adams to W. J. Sowden, 7 December, 1916; T. Gill to General Secretary, Public Library, Museum and Art Gallery, 15 December, 1916. Docket no.103/1917/3748; 22524, State Records Office, Adelaide.

5. 'Proposals of the Museum Director', 10 January, 1917', Docket no.103/1917, State Records Office, Adelaide.

6. This suggestion appears to have been made by the Board's Chairman. Docket no.103/1917, State Records Office, Adelaide.

journal would raise the status of the Museum:

> An individual may become quite famous locally but unless he publishes the results of his labours he will never be widely recognised and the same is true of an Institution. The more widely known a Museum becomes, the better the opportunities for exchange and of attracting experts to examine and report upon special collections or subjects.

Fourthly, Waite stressed the fact that without a scientific journal, the South Australian Museum was significantly out of step with other Australasian museums; it was the only museum in the region which was in a position to publish a scientific journal, but did not. Brisbane, Sydney, Melbourne and Perth Museums in Australia, and Wellington and Canterbury in New Zealand, all published their journals, as did the 'principal Museums in other British Colonies ... and most Foreign Museums'. Waite's final point was that the journal would provide a 'special inducement' for Museum staff to publish their researches 'in a publication with which they were so closely associated'. This, he considered, 'would prove a stimulus for diffident or indifferent workers', but added diplomatically '(I may here be thinking of the future)'. Perhaps one of Waite's most potent arguments though, was stated almost as an afterthought:

> At present no new species can, for example, be constitutionally published until December of any one year, when the volume of the Royal Society of South Australia appears; and recognising this, the Museum Committee recently authorised the publication of new records, out-side the pages of the Society.[7]

These arguments seemed convincing but Waite was immediately countered by his authoritative Curator of Insects, Arthur M. Lea. A prolific author of scientific papers, Lea contrasted the advantages of a Royal Society, as against a Museum, publication. His conclusion was that the latter still offered the best and most dependable forum for Museum publications and that the Royal Society's library could not be bettered by the Museum's. Lea's forthright letter to Waite ended:

> The scientific workers in South Australia are insufficient in numbers to justify two publications dealing with practically the same subjects.[8]

The Museum Committee met on 31 January, 1917, the day following Lea's letter, and decided that:

> consideration of the question of altering the existing arrangements whereby scientific papers by Museum Officials are published in the Transactions of the Royal Society of South Australia be deferred until after the European War.[9]

Waite was resigned to this setback and continued with plans for the publication by the Royal Society of the first illustrated catalogue of South Australian fish species. It appears to have been his specialised requirements for printing illustrations to this catalogue which finally caused the Museum Committee to reconsider Waite's suggestion for a museum journal. Events took a sudden turn. Waite's diary entry for Thursday, 18 September, 1917 recorded that:

> the Committee will recommend that a publication be issued by the Museum, my figure of £100 annually being accepted as a basis.[10]

Two days later the matter was dealt with by the full Board of the Public Library, Museum and Art Gallery. Waite recorded the result:

> Board granted me the £25 requested for preparing drawings of fishes and approved my suggestion to issue a Museum "Bulletin". I am to draw up necessary details as size and general "get up". My present idea is for No.1 to contain my review of Aust. Typhlopidae [Fig. 2], Notes on Fishes by McC [McCulloch] and W. [Waite] and possibly a catalogue of Australian lizards now being prepared by Zietz.[11]

The funds for the journal were to be drawn from the Museum's share of the Morgan Thomas Bequest Account, which had been invested in securities since its establishment in 1903. At this early stage, the 100 pounds set aside for the *Records* represented about one-tenth of the annual income derived from the Museum's share of the bequest (Hale 1956: 75, 136).

It was considered necessary by the full Board of Governors to mark their shift in publishing policy in a letter to the Royal Society. The Board's letter contained a hint of apology,

> gratefully acknowledging its indebtedness to the society for making it possible for so many years through the medium of its Journal to place before the public the results of the scientific research of its Museum officers. The benefit possibly may have been of a mutual character, but the Board is sensible of the fact that hitherto the expense of publishing at its own expense was not possible.

7. 'Proposals of the Museum Director', 10 January, 1917, Docket no.103/1917, State Records Office, Adelaide.
8. A.M. Lea to E. R. Waite, 30 January, 1917, Docket no.103/1917, State Records Office, Adelaide.
9. 'Scientific Publications by Museum Officers', 1 February, 1917, Docket no.103/1917, State Records Office, Adelaide.
10. Waite, E. R. Diary no.64, 18 September, 1917. AA356, Anthropology Archives, South Australian Museum, Adelaide.
11. Waite, E. R. Diary no.64, 21 September, 1917. AA356, Anthropology Archives, South Australian Museum, Adelaide.

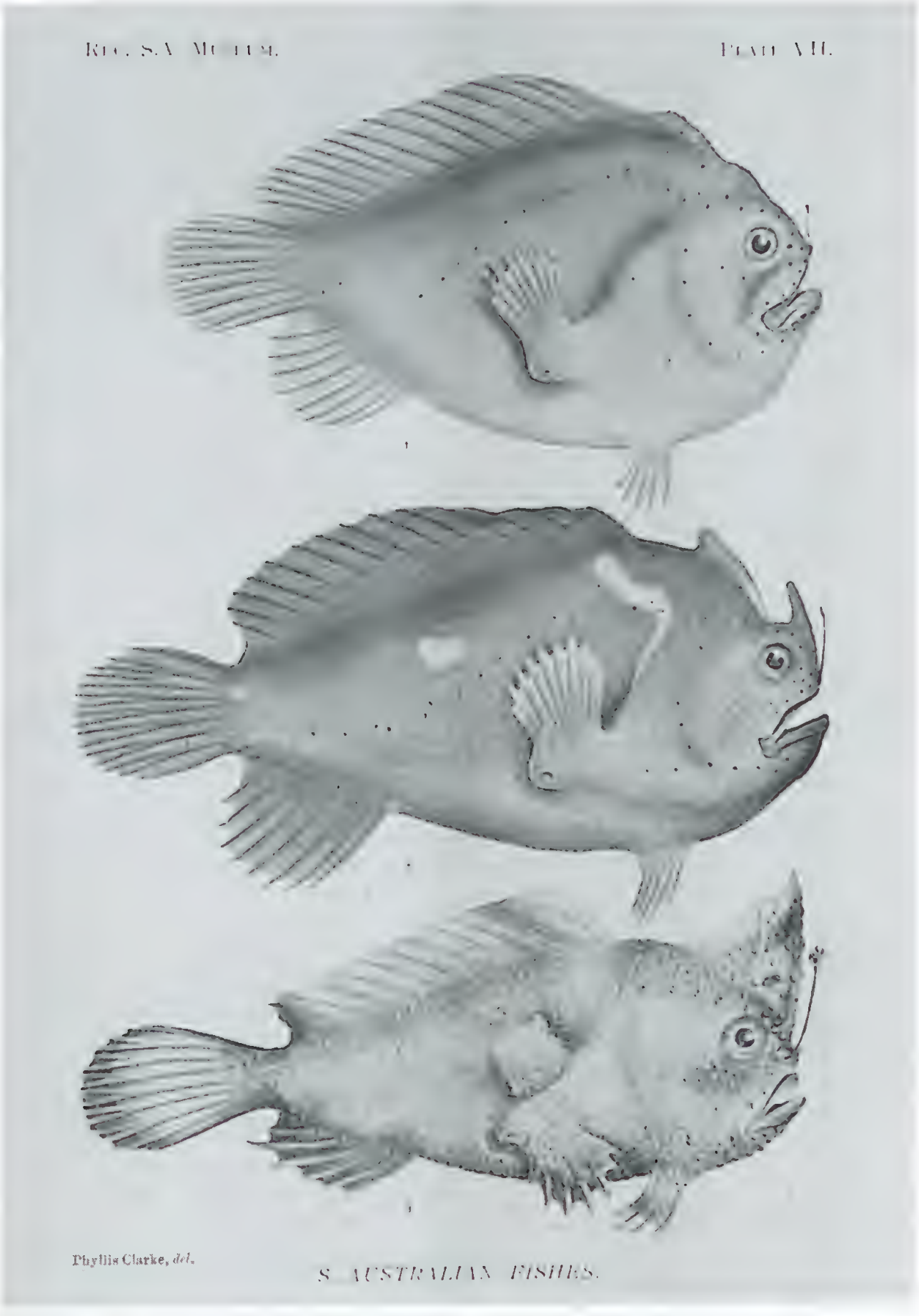

FIGURE 2. A copy of Plate VII from McCulloch and Waite, Some New and Little-known Fishes from South Australia, *Records of the South Australian Museum*, Volume 1(1).

> The Board still hopes, however, that it may continue to offer for publication in the Transactions of the Royal Society of S.A. papers that will be regarded as acceptable.[12]

Such deference was irritating to Waite, who was conscious of the Museum's historic role in providing the core of the *Transactions*' scientific publications. The careful reference to 'mutual benefit' was insufficient for him, as revealed by his private journal entry, following the Museum Committee meeting which drafted the letter:

> Howchin said that the Roy. Soc. would not in future print Museum material & got a vote of thanks passed to the Soc. for publishing the Museum papers in the past, nothing said as to the value of the Museum contribution to the Society!![13]

By early 1918 Waite had established the 'size, style, type, etc.' for the new journal, and had been able to assemble material for the inaugural issue. He estimated its cost at ninety pounds. He also prepared a statement for the Museum Committee, of which Stirling was now the Chairman, outlining the character of the new publication. It was

> to be devoted to research work of the Museum Staff, including records of expeditions, descriptions and illustrations of objects in the Museum or the property of others, occasional notes, and the work of outside investigators, dealing with Museum Material ... The publication is to be edited by the Museum Director and to be issued in parts at intervals when sufficient matter is available: a suitable number of such parts to form a volume.[14]

An order was subsequently placed with the Adelaide printers Hassell and Son, and by April 14th Waite had corrected the first proofs. Two weeks later he received the news that the opportunity for a collecting expedition to the south-west Pacific had arisen. Progress on the journal was now urgent, as Waite's diary entry for May 2nd reveals: 'Now pushing on "Museum Records" in case I have to go away'.[15]

The ensuing six week period was a race against time for Waite, with various administrative duties to finalise, as well as final arrangements for the journal. He pressured Hassells to publish as soon as possible; finally they were able to produce the inaugural issue of the *Records*, together with offprints, on the morning of June 24th, 1918 (the official publication date was recorded as May 24th). At 4.30pm that June afternoon Waite left by train to Melbourne, en route to his disembarkation for the Pacific islands expedition. The Museum's Annual Report was written aboard ship near Hinchinbrook Island, and posted from Cairns.

The first issue of the *Records* contained significant scientific contributions to the fields of ichthyology and entomology. Contributions to other branches of natural science and to anthropology followed in the remaining three issues of the first volume, published between 1918 and 1921. Waite was a prominent contributor to this and subsequent volumes. His catalogue of South Australian fishes, prepared with McCulloch for the first issue, was subsequently reprinted in 1923 as one of the first Handbooks of the Flora and Fauna of South Australia. Another prominent contributor to the early issues of the *Records* was Arthur Lea, whose strong advocacy of the *Transactions* had presented a major obstacle to Waite's initiative. Lea contributed a major summary of South Australian coleoptera to the first four parts of the *Records*.

The *Records of the South Australian Museum* enjoyed a decade of healthy activity under Waite's editorship until his sudden death in 1928. The mantle then passed to Herbert Hale and eventually to Norman Tindale, who took the journal through to the 1960s. Waite's model for the journal as a forum for the publication of the 'research work of Museum staff' has been largely adhered to throughout its history, although the work of 'outside investigators' has become more prominent in recent decades. At the close of the first decade, three volumes of the *Records* had been published, comprising sixty-seven papers, of which forty-one had been prepared by members of the Museum staff. The remaining papers, by external researchers, dealt with material in the Museum collections (Hale 1956: 136).

As a scientist who had published widely in both hemispheres before his arrival in Adelaide, Waite did not perceive or impose any restriction on the journal's geographical scope. In spite of this, the journal naturally achieved a South Australian focus. Waite's eclecticism informed the journal's scientific trajectory through the 1920s and beyond. Flute-player, theatre-goer, motor-cycle rider, aquarium-keeper, Waite published in several branches of natural history as well as in anthropology. With Edward Stirling too ill to

12. J. R. G. Adams to the Hon. Secretary, Royal Society of South Australia. 18 February, 1918, Docket no.103/1917, State Records Office, Adelaide.
13. Waite, E. R. Diary no.64, 6 February, 1918. AA356, Anthropology Archives, South Australian Museum, Adelaide.
14. E. R. Waite to Museum Committee, 31 January, 1918, Docket no.103/1917, State Records Office, Adelaide.
15. Waite, E. R. Diary no.64, 2 May, 1918. AA356, Anthropology Archives, South Australian Museum, Adelaide.

complete his paper on the Aboriginal toas acquired from the missionary J. G. Reuther, Waite became the paper's co-author and supervised its 1919 publication in the *Records*' second Part. Thus from the first volume, the journal represented the main branches of scientific and cultural investigation at the South Australian Museum. Tindale's era strengthened this cross-disciplinary representation; he published strongly in entomology, anthropology and, following his 1929 Devon Downs excavation, in archaeology.

The *Transactions of the Royal Society* did not suffer the decline which might have been anticipated. The revitalisation of South Australian academic and research zoology which occurred during the 1920s assured the Society of a continuing flow of papers. Museum scientists continued to publish in the *Transactions* as well, a trend which has continued until the present.

After three-quarters of a century the five main benefits which Waite predicted would flow from the Museum's publication of its own scientific journal all appear to have been realised. The pressure on the *Transactions* was relieved, Museum staff were offered a ready inducement to publish, the scientific status of the Museum was enhanced and it was placed on a par with its sister institutions. Most tangibly, the Museum's library benefited from a series of exchanges made possible by the production of the *Records*. Hundreds of periodicals have been received in direct exchange for the twenty-seven volumes of the *Records* published since 1918. These volumes have contained more than 670 scientific papers, shortly to be listed in a published cumulative index assembled by Stan Edmonds (in prep.).

It is worth noting that the impetus for the establishment of the *Records* came from the vigorous efforts of Edgar Waite, newly arrived in Adelaide. His impact on the publishing program of the South Australian natural science community can be likened to that of Ralph Tate a generation earlier. Both were accomplished natural scientists with eclectic interests, extensive publishing experience and strong connections with national and international scientific communities. Both succeeded in reshaping the public face of scientific research in South Australia.

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REVISION OF THE HALIPLIDAE (COLEOPTERA) OF THE AUSTRALIAN REGION AND THE MOLUCCAS.

BERNHARD J. VAN VONDEL

VONDEL, B. J. VAN, 1995. Revision of the Haliplidae (Coleoptera) of the Australian region and the Moluccas). *Records of the South Australian Museum.* **28**(1): 61–101.

The Haliplidae of the Australian region and the Moluccas are revised. Fifteen species are recognized, of which *Haliplus wattsi*, *Haliplus hydei*, *Haliplus storeyi* and *Haliplus timmsi* are described as new. A key to the species is provided and distribution maps are given. Types of most species have been studied. Lectotypes have been designated for *Haliplus signatipennis* Régimbart and *Haliplus oberthuri* Guignot. *Haliplus nicholasi* Watts is considered a junior synonym of *Haliplus ferruginipes* Régimbart and *Haliplus nigrolineatus* Wehncke a junior synonym of *Haliplus testudo* Clark.

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Recently Watts (1988) revised the Australian Haliplidae. He recognized eight species, of which four were described as new. Because there are a few more species outside Australia, but belonging to the Australian faunal region, it seemed useful to me to treat and illustrate these species together with the Australian ones. Furthermore I would like to propose some additions to Watts' revision.

This revision treats the species present in Australia, New Guinea, Seram and New Caledonia. No Haliplidae are known from the other islands in the region or from New Zealand.

Methods

The methods used are those of Vondel (1991). The terms used are explained in Figs 1 and 2.

Material

Material from the region, especially outside Australia, is usually rare in the collections of the institutions listed below. Expeditions by Michael Balke and Lars Hendrich to West New Guinea, very successful in collecting various water beetles, did not produce Haliplidae. Manfred Jäch could collect only one *Haliplus* during his recent water beetle expedition to the Central Moluccas (Ambon, Seram).

Data on ecology are seldom present on labels. According to Lawrence *et al.* (1987: 322) Australian Haliplidae are algal-feeders and bottom-dwellers and are usually found in lentic fresh water, which in general also applies to most non-Australian members of this family.

The material I had access to originates from the following institutional and private collections:

ANIC – Australian National Insect Collection, Canberra, Australia.

BMNH – Natural History Museum, London, UK.

BPBM – B. P. Bishop Museum, Honolulu, Hawaii, USA.

CNCI – Canadian National Collections, Ottawa, Ontario, Canada.

CV – Collection B. J. van Vondel, Hendrik-Ido-Ambacht, The Netherlands.

CW – Collection Dr C. H. S. Watts, Adelaide, South Australia, Australia.

ISNB – Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium.

MCZC – Museum of Comparative Zoology, Cambridge, Massachusetts, USA.

MNHN – Muséum National d'Histoire Naturelle, Paris, France.

MUNC – Memorial University of Newfoundland, St. John's, Canada.

MVMA – Museum of Victoria, Abbotsford, Victoria, Australia.

NHMV – Naturhistorisches Museum, Vienna, Austria.

QMBA – Queensland Museum, South Brisbane, Queensland, Australia.

QPI – Queensland Department of Primary Industries, Mareeba, Queensland, Australia.

RMNH – Nationaal Natuurhistorisch Museum, Leiden, Netherlands.

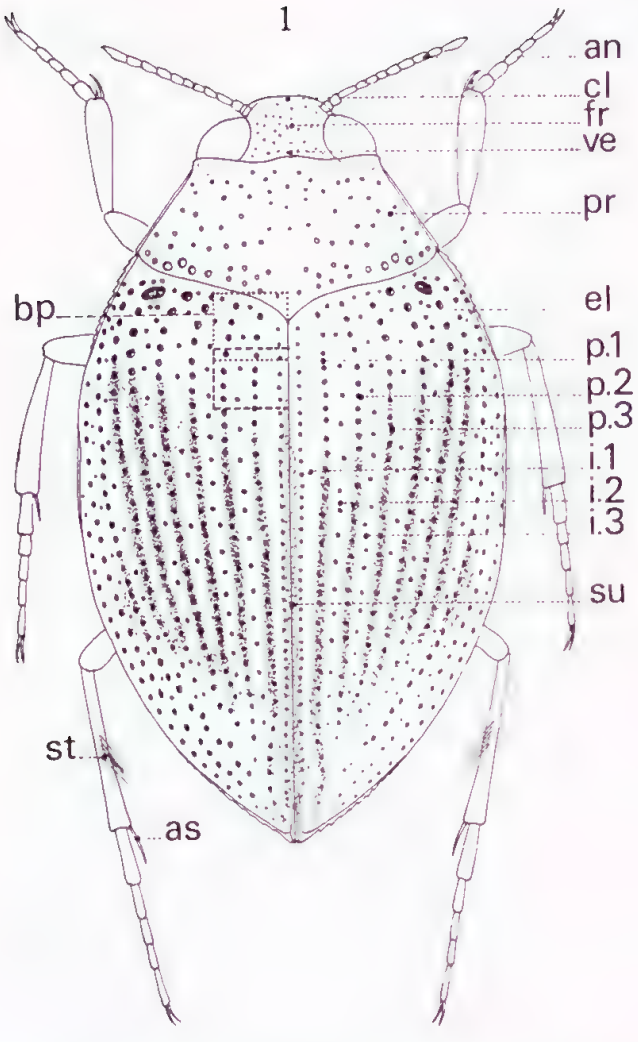


FIGURE 1. *Haliplus wattsi*, dorsal view: an, antenna; as, apical spur; bp, location of basal punctures, illustrated for each species; cl, clypeus; el, elytron; fr, frons; i.1, i.2, i.3, etc, interval 1, 2, 3 etc; pr, pronotum; p.1, p.2, p.3, etc., primary puncture-row 1, 2, 3 etc; st, setiferous striole; su, suture; ve, vertex.

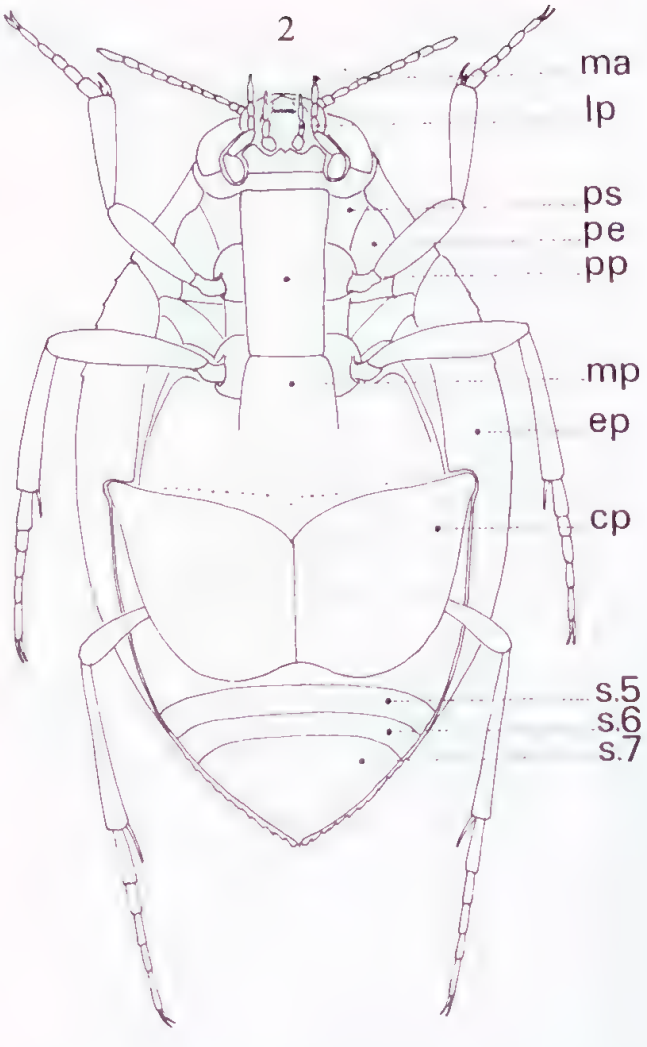


FIGURE 2. *Haliplus wattsi*, ventral view: cp, metacoxal lobe (or coxal plate); ep, elytral epipleuron; mp, metasternal process; pe, proepisternum; pp, prosternal process; ps, prosternum; s.5, s.6, s.7, sternite 5, 6, 7 (last sternite).

SAMA – South Australian Museum, Adelaide, South Australia, Australia.

SMFD – Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt am Main, Germany.

UQIC – University of Queensland, Brisbane, Queensland, Australia.

UZMH – Zoological Museum, Helsinki, Finland.

ZMUC – Zoological Museum, Copenhagen, Denmark.

Systematic Section

The Haliplidae are represented in this region by only one genus: *Haliplus* Latreille. The genus *Haliplus* is divided into six subgenera, of which three occur in the Australian region. Guignot (1935a) erected the subgenus *Phalilus* for *H. oberthuri*. Guignot (1955) assigned *H. bistriatus*, *H. fuscatus* and *H. gibbus* to the subgenus *Neohaliplus* Netolitzky (1911).

The remaining species belong to the subgenus *Liaphlus* Guignot (1928).

The species below assigned to the subgenera *Phalilus* and *Neohaliplus* seem to form a group having a combination of characters, which is so far not found outside the Australian region. Most characteristic of the species in this group is the lack of genal lines behind the eyes while all other world Haliplidae have one or two genal lines. The type-species of *Neohaliplus*: *Haliplus lineatocollis* (Marsham) has two genal lines. Further study, based on a worldwide survey, is needed to determine if the Australian species indeed belong

to *Neohaliplus*, as they show strong differences with the palaearctic species of *Neohaliplus*. The species in the subgenus *Liaphlus* have two genal lines. Representatives of *Liaphlus* in the presently used context are spread worldwide, but according to Beutel & Ruhnau (1990) there is, so far, no evidence for the monophyly of this subgenus.

The Australian subgenera in their present context can be distinguished by the following characters:

1 — Pronotum with basal plicae (Fig. 3), right paramere of male without apical digitus (Fig. 14)... 2
— Pronotum without basal plicae (Fig. 70), right paramere of male with apical digitus (Fig. 78)..... .....*Liaphlus*
2 — Last abdominal sternite with medial ridge (Fig. 10, 22).....*Phalilus*
— Last abdominal sternite without medial ridge..... .....*Neohaliplus*

After the examination of about 390 specimens, including types of all species except *Haliplus ferruginipes* Régimbart and *Haliplus bistriatus* Wehncke, I recognize the following species:

Haliplus oberthuri (*Phalilus*) Guignot, 1935b
Haliplus storeyi (*Phalilus*) **sp. n.**
Haliplus hydei (*Neohaliplus*) **sp. n.**
Haliplus fuscatus (*Neohaliplus*) Clark, 1862
Haliplus gibbus (*Neohaliplus*) Clark, 1862
Haliplus bistriatus (*Neohaliplus*) Wehncke, 1880
Haliplus australis (*Liaphlus*) Clark, 1862
Haliplus wattsi (*Liaphlus*) **sp.n.**
Haliplus testudo (*Liaphlus*) Clark, 1862
Haliplus nigrolineatus Wehncke, 1883. **syn. n.**
Haliplus signatipennis (*Liaphlus*) Régimbart, 1891
Haliplus ferruginipes (*Liaphlus*) Régimbart, 1891
Haliplus nicholasi Watts, 1988. **syn. n.**
Haliplus alastairi (*Liaphlus*) Watts, 1988
Haliplus timmsi (*Liaphlus*) **sp. n.**
Haliplus stepheni (*Liaphlus*) Watts, 1988
Haliplus sindus (*Liaphlus*) Watts, 1988

Key To The Species Of Haliplidae Of The Australian Region And The Moluccas

1 — Pronotal base usually with longitudinal plicae. Between plicae strongly impressed (Fig. 3). Prosternal process posteriorly strongly impressed in middle (Fig. 7).....2
— Pronotal base without longitudinal plicae (Fig. 70). Prosternal process not strongly impressed in middle (Fig. 74).....8
2 — Last abdominal sternite with strong longitudinal ridge or keel.....3
— Last abdominal sternite without ridge or keel.....4
3 — Pronotal plicae absent or hardly recognizable (Fig. 15), base of pronotum strongly and coarsely punctured. Last sternite with clearly visible ridge in posterior half, which is hardly visible in lateral view (Figs 22, 23).....*Haliplus storeyi*
— Pronotal plicae long and strongly bent (Fig. 3), base of pronotum moderately punctured. Last sternite with strong ridge, which is also clearly visible in lateral view.....*Haliplus oberthuri*
4 — Pronotal plicae long, base of elytral puncture-row 5 strongly grooved.....5
— Pronotal plicae short and straight, base of elytral puncture-row 5 at most slightly grooved.....6
5 — Pronotal basal plicae straight at base and anteriorly hardly curved. Pronotum basally and anteriorly at most vaguely darkened (Fig. 27). Elytron with vague, hardly interrupted, dark lines on primary puncture-rows. Metasternal process in middle with dense hairy punctures (Fig. 31). Male: protarsal claws clearly unequal in length (Fig. 30); left paramere without recognizable solid digitus and without hairs on apex (Fig. 34); penis narrow, tip slightly widened, inner side gradually curved to top (Fig. 35).....*Haliplus hydei*
— Pronotal basal plicae curved and strongly bent inwards before base. Pronotum distinctly darkened along base and along anterior edge (Fig. 57). Elytron with distinct interrupted dark lines on primary puncture-rows. Metasternal process in middle without dense hairy punctures (Fig. 61). Male: protarsal claws equal in length (Fig. 60); left paramere with solid digitus (sometimes wide and then not always clearly recognizable) with hairs on top (Fig. 64 or 67); penis wider in middle or nearly parallel, inner side abruptly bent before top (Fig. 65 or 68).....*Haliplus bistriatus*
6 — Females.....*Haliplus fuscatus* or *H. gibbus*
— Males.....7
7 — Penis very narrow (Fig. 45).....*Haliplus fuscatus*
— Penis broad (Fig. 55).....*Haliplus gibbus*
8 — Pronotum with longitudinal dark mark in middle.9
— Pronotum with dark mark at most anteriorly.....10
9 — Secondary punctures on elytron weak and sparse. Anterior elytral margin at most weakly serrate (Fig. 97). Specimens from New Guinea..... .....*Haliplus signatipennis*
— Secondary punctures on elytron very strong and dense, almost as strong as primary punctures. Anterior elytral margin clearly serrate (Fig. 106). Specimens from Seram.....*Haliplus signatipennis*
10 — Uniformly yellow-brown. Pronotum with lateral margins serrate (Fig. 147). Prosternal process impressed in middle (Fig. 151).....*Haliplus sindus*
— Elytron usually with dark marks or stripes, but at least with darkened punctures. Pronotum with lateral margins not serrate. Prosternal process not impressed in middle.....11

11 — Elytral puncture-row 5 basally ending in deep transverse impression (Fig. 118).....12
— Elytral puncture-row 5 basally at most with few punctures standing close together or more or less confluent.....14

12 — Elytron with dark band along base reaching to puncture-row 5 (Fig. 136). Pronotum with or without anterior dark mark (Fig. 136).....*Haliplus stepheni*
— Elytral base at most with dark mark near puncture-row 4. Pronotum without marks.....13

13 — Metasternal process flat, at most with some strong punctures on both sides close to each other (Fig. 122). Elytron with secondary punctures near base of primary row 5 strong, basal punctures of primary row 6 strong. Elytron usually with well defined maculation (Fig. 118)...*Haliplus alastairi*
— Metasternal process with clear pit on both sides (Fig. 131). Elytron with secondary punctures near base of primary row 5 weak. Basal punctures of primary row 6 weak. Elytron usually with interrupted dark lines, which are rarely connected by vague marks (Fig. 127).....*Haliplus timmsi*

14 — Elytron with extensive maculation, base broadly darkened to puncture-row 5 (Fig. 112).....*Haliplus ferruginipes*
— Elytron without extensive maculation, base not distinctly darkened.....15

15 — Proepisternum strongly and densely, sometimes even coarsely punctured. Prosternal process usually slightly but gradually widening anteriorly, not clearly narrowed before coxae (Fig. 83). Last sternite with strong punctures on most of its surface. Male: left paramere with small solid digitus (Fig. 85).....*Haliplus wattsi*
— Proepisternum at most weakly punctured in anterior part. Prosternal process slightly narrowed before coxae, more or less sinuate, anteriorly about as wide as posteriorly. Last sternite with moderately strong to weak punctures on about apical half.....16

16 — Elytron usually without dark stripes on primary puncture-rows, only punctures darkened (Fig. 70). Row of secondary punctures along suture very dense and in irregular row, elytral interval 2 with complete row of secondary punctures, interval 4 with sparser puncture-row. Metasternal process with lateral rows of strong punctures, which usually lie in slight impression (Fig. 74). Male: left paramere with small solid digitus (Fig. 76).....*Haliplus australis*
— Elytron with continuous or hardly interrupted dark stripes on primary puncture-rows (Fig. 88). Row of secondary punctures along suture dense and in regular row, interval 2 with about 6–12 punctures and interval 4+6 only anteriorly with a few punctures. Metasternal process with clear lateral impressions (Fig. 92). Male: left paramere without solid digitus (Fig. 94).....*Haliplus testudo*

Description Of Species

Haliplus oberthuri Guignot
(Figs 3–14)

Haliplus oberthuri Guignot, 1935a: 165. Lectotype ♂ (here designated) 'N. Caled.; TYPE; Det. Dr Guignot, *Haliplus* sg. *Phalilus oberthuri* Guign., type; *bistriatus* Fauvel' [Marais de l'anse Vata près Nouméa] (MNHN)[examined]

Haliplus bistriatus; sensu Fauvel 1883: 335, nec Wehncke 1880. [Misidentification]

Haliplus bistriatus; Guignot 1935a: 36, 1935b: 164; Watts 1988: 25.

Haliplus oberthuri; Guignot 1955: 290.

Diagnosis

This species is easy to distinguish from other species with pronotal plicae by the strong ridge on last sternite.

Description

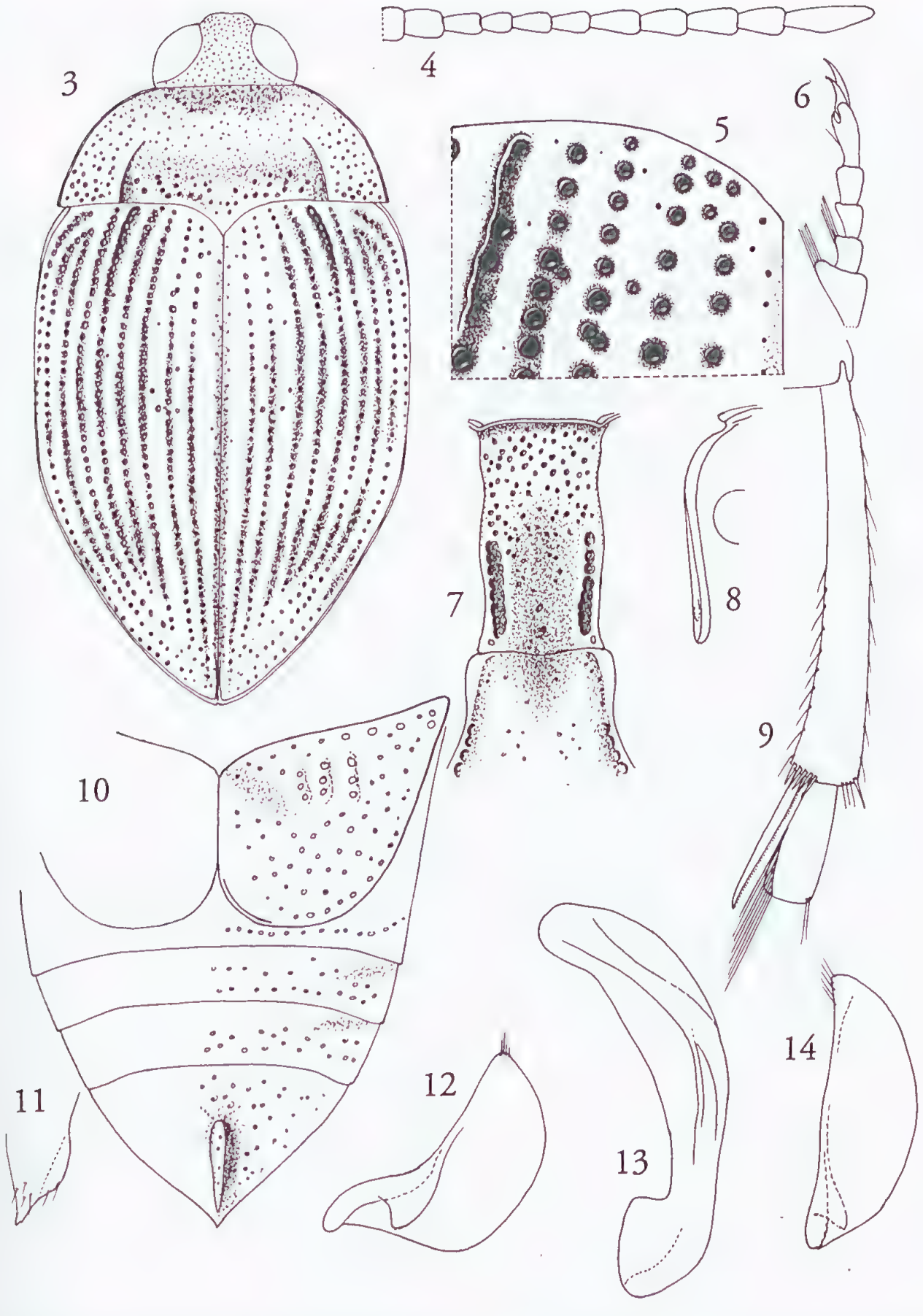
Length 3.0–3.3 mm, width 1.6–1.9 mm. Body broad, parallel in middle (Fig. 3).

Head: Yellow-red, antenna yellow (Fig. 4), palpi yellow, maxillary palpus with last segment more than half length of penultimate segment. Punctation anteriorly dense, sparser on vertex. Distance between eyes 1.2x width of one eye.

Pronotum: Yellow-red, dark blotch along anterior margin. Lateral border strongly convex, finely margined, front corners strongly bent downwards. Base wider than base of elytra, long curved plicae at base reaching over half length of pronotum, strongly impressed between plicae. Punctation on disc dense, strong basally (Fig. 3).

Elytra: Yellow-red, dark lines on primary puncture-rows 1+2 interrupted between dark punctures in basal part, on rows 3–7 continous, on rows 8+9 widely interrupted (Fig. 3). Primary punctures except in basal part of row 1+2 very dense and strong. About 45 punctures in row 1. Basal 6–10 punctures of row 5 confluent, forming clear plica. Secondary punctures very sparse and usually very small. All punctures darkened except in unstriped parts of outer rows. Suture apically briefly margined. Laterally completely margined, margin in middle hidden from above.

Underside: Body yellow-red; legs yellow-red, darkened towards coxae; elytral epipleura yellow, reaching sternite 5, strongly punctured in anterior and posterior part. Prosternal process wide and irregularly parallel-sided, strongly impressed in



FIGURES 3–14. *Haliplus oberthuri*, Paralectotype ♂: **3**, dorsal view; **4**, antenna; **5**, punctures near elytral base and suture; **6**, tarsus of male fore-leg; **7**, prosternal and metasternal process; **8**, prosternal process in lateral view; **9**, hind tibia; **10**, metacoxal lobes and sternites; **11**, last sternite in lateral view; **12**, left paramere; **13**, penis; **14**, right paramere.

apical half, strong punctured grooves on marginal ridges, densely and strongly punctured on anterior half, clearly margined on anterior edge (Fig. 7, 8). Metasternal process with lateral ridges, formed by row of strong punctures, strongly impressed towards apical part, very sparsely and weakly punctured (Fig. 7). Metacoxal lobes widely rounded at apical part, finely margined on apical corner, punctures fairly strong and dense, in central part some coarse punctures (Fig.10). Punctures on sternite 5+6 not forming clear row, last sternite with strong ridge in middle (Fig.10, 11). Hind tibia without setiferous striole, longer tibial spur clearly longer than first tarsal segment (Fig. 9).

Male: Pro- and mesotarsomeres 1–3 widened, tarsomere 1 more dilated ventrally, only tarsomeres 1+2 with sucker hairs on ventral side. Protarsal claws unequal in length (Fig. 6), mesotarsal claws slightly unequal in length. Penis and parameres as in Figs 12–14.

Biology

The type material is found in a marsh (Fauvel 1883: 335).

Distribution (Fig. 153)

New Caledonia. Australia: Queensland. The specimen I have seen labelled 'New Zealand, N. Cal.' is obviously mislabelled.

Material examined: New Caledonia: 1 ♂, lectotype; 1 ♂, N.elle Caledonie, Noumea, ex coll. Gambey, R. Oberthur ded., paratype, *Haliplus* (*Phalilus*) *oberthuri* Guignot (MNHN); 1 ♂, Coll. E. Witte, Australien; 1 ♂, Coll. E. Witte, *bistriatus*, N. Cal., N. Seeland [obviously mislabelled](SMFD). Australia: 1 ♀, Yungaburra, Q., Atherton Tab., Harvard Exp. Darlington, *Haliplus stepheni* ms.nom, det. C. Watts (MCZC); 1 ♂, Bne [Brisbane], *H. fuscatus* Clark, *Haliplus stepheni ms.nom*, det. C. Watts 84 (CV); 1 ♂, unlabelled (QMBA).

***Haliplus storeyi* sp.n.**

(Figs 15–26)

Type material: ♂ Holotype: Australia, N.T., 6 km E. Humpty Doo, 9.ii–4.iii.1987, R. I. Storey, *Haliplus bistriatus* Wehncke, det. C. Watts 87, T.12700 (QMBA); Paratypes: 5 ♀, same data as holotype (3 in QPI, 2 in CV).

Diagnosis

This species differs from other species with pronotal plicae by the ridge on last sternite and from *H. oberthuri* by the faintly impressed pronotal plicae and its smaller size.

Description

Length 2.4–2.5 mm, width 1.2–1.3 mm. Body broad, parallel in middle (Fig. 15).

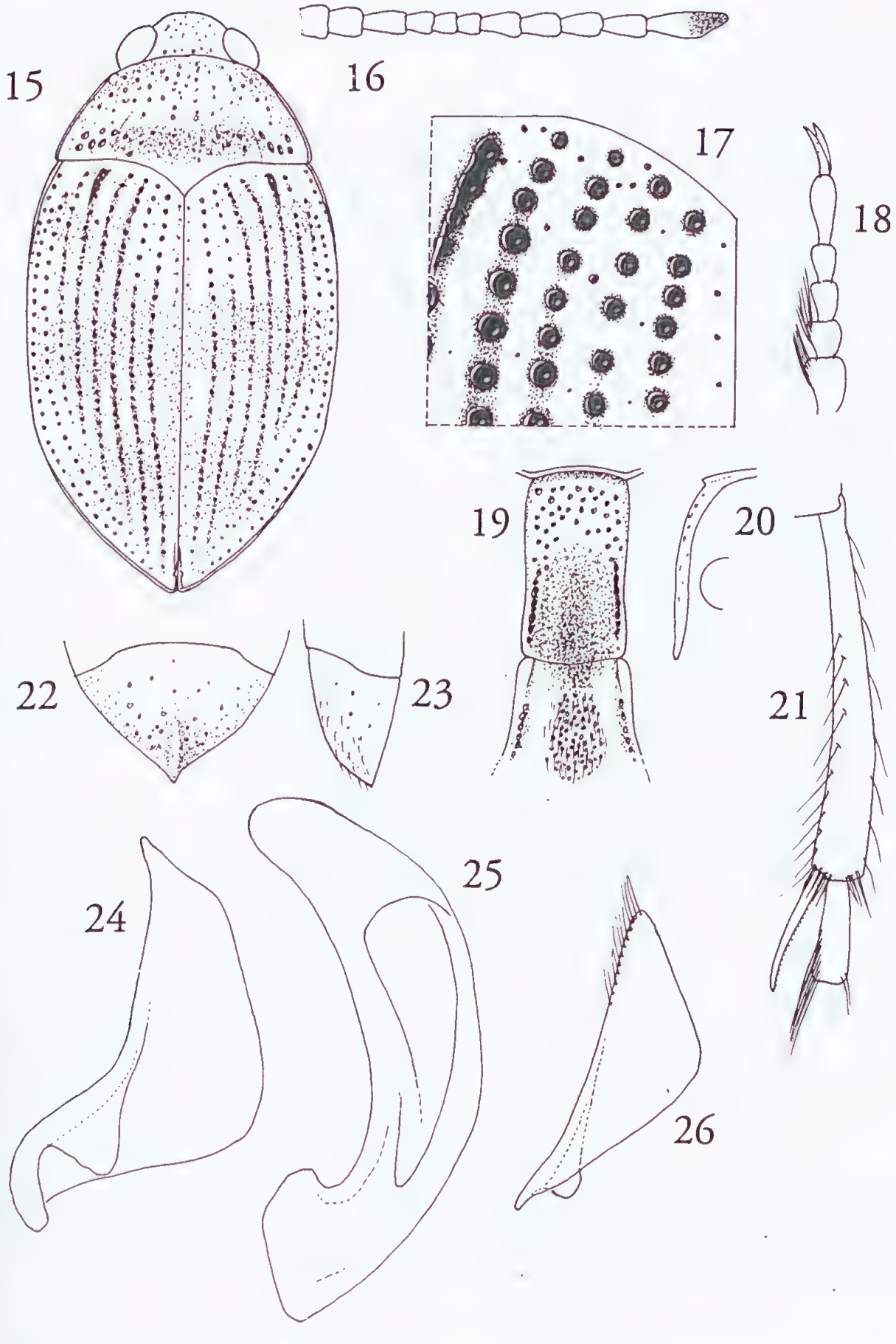
Head: Yellow-red, weakly punctured. Antenna yellow, distal half of last segment darkened (Fig. 16), palpi yellow, maxillary palpus with last segment about half length of penultimate segment. Distance between eyes 1.5x width of one eye.

Pronotum: Yellow-red to yellow-brown. Lateral borders strongly convex, finely margined, front corners strongly bent downwards, hind corners rectangular to slightly rounded. Long plicae at base hardly visible or usually absent. Strongly impressed along base. Moderately strongly, along base strongly, densely and in hind corners coarsely punctured (Fig. 15).

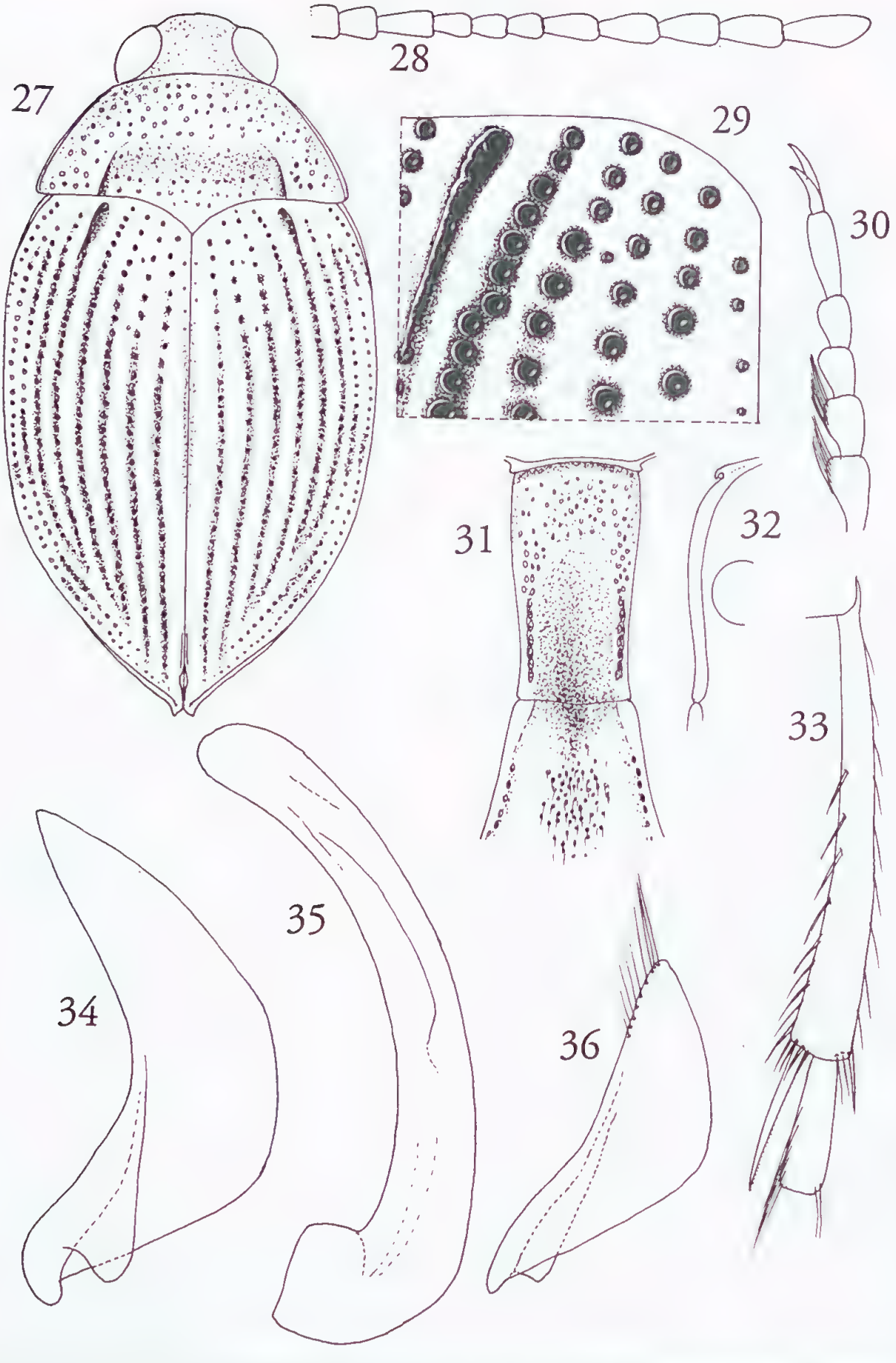
Elytra: Yellow-red to yellow-brown, vague transverse maculation in middle and in apical part (Fig. 15). Primary punctures strong and moderately dense. About 29 punctures in row 1. Basal 6–7 punctures of row 5 confluent, forming clear plica. Secondary punctures sparse and usually very small along suture, almost absent on intervals. All punctures darkened except in parts of outer rows. Apical part of suture shortly margined and with blunt dorsal tooth. Completely margined, margin in middle invisible from above.

Underside: Body yellow-brown to brown, elytral epipleura yellow-brown, reaching sternite 5, with strong puncture-row in posterior part and two strong rows in anterior part. Legs yellow-red to yellow-brown, slightly darkened towards coxae. Prosternal process wide and parallel-sided, strongly impressed in apical half, strong punctured grooves on marginal ridges, densely and strongly punctured on anterior half, clearly margined on anterior edge (Figs 19, 20). Metasternal process with lateral ridges, formed by row of strong punctures, only impressed anteriorly, very densely punctured and hairy in middle (Fig. 19). Metacoxal plates not reaching sternite 5, widely rounded at apical part, clearly margined along posterior edge, punctures fairly strong. Fine punctures on sternite 5+6 not forming clear row, last sternite with keel in apical half, strongly punctured (Figs 22, 23). Setiferous striole on dorsal face of hind tibia on about half length, longer tibial spur longer than first tarsal segment (Fig. 21).

Male: Pro- and mesotarsomeres 1–3 widened, tarsomere 1 more dilated ventrally, only



FIGURES 15–26. *Haliplus storeyi*, Holotype ♂: **15**, dorsal view; **16**, antenna; **17**, punctures near elytral base and suture; **18**, tarsus of male fore-leg; **19**, prosternal and metasternal process; **20**, prosternal process in lateral view; **21**, hind tibia; **22**, last sternite; **23**, last sternite in lateral view; **24**, left paramere; **25**, penis; **26**, right paramere.



FIGURES 27–36. *Haliplus hydei.*, Holotype ♂; **27**, dorsal view; **28**, antenna; **29**, punctures near elytral base and suture; **30**, tarsus of male fore-leg; **31**, prosternal and metasternal process; **32**, prosternal process in lateral view; **33**, hind tibia; **34**, left paramere; **35**, penis; **36**, right paramere.

tarsomeres 1+2 with sucker hairs on ventral side. Protarsal claws equal in length (Fig. 18). Penis and parameres as in Figs 24–26.

Biology
Unknown

Distribution (Fig. 155)
Only known from Humpty Doo, Northern Territory, Australia.

***Haliplus hydei* sp.n.**
(Fig. 27–36)

Type-material: Holotype ♂: Cardstone, Qld, 17–23.ii.1966, K. Hyde, *Haliplus bistriatus* Wehncke det. Watts, ANIC No. 111 (ANIC). Paratypes: 10 ♂, 11 ♀, Same data as holotype (17 in ANIC, 4 in CV); 1 ♂, Cardstone, 32 km S. of Ravenshoe, Q, 17.38S, 145.29E, 14.ii.1968, K. Hyde (ANIC); 3 ♂, 1 ♀, Australia, N. Qld, Pinnarendi Stn, 60 km W. of Mt Garnet, 7.ii.1989, D. Heiner (3 in QPI, 1 in CV).

Diagnosis
This species can be distinguished from *H. bistriatus*, *H. fuscatus* and *H. gibbus* by the pronotal plicae, being long and straight at base and male with clearly unequal protarsal claws.

Description
Length 2.7–3.0 mm, width 1.4–1.6 mm. Body oval, parallel to subparallel in middle (Fig. 27).

Head: Yellow-red to yellow-brown, weakly punctured. Antenna yellow (Fig. 28). Palpi yellow to yellow-brown. Distance between eyes about 1.2–1.6x width of one eye.

Pronotum: Yellow to yellow-brown, strongly impressed base between long, curved to almost straight plicae (Fig. 27). Lateral borders finely margined, hind corners rectangular to slightly rounded. Anterior half densely punctured; front and hind corners strongly punctured; basal depression weakly punctured.

Elytra: Yellow-brown to yellow-red. Vague dark hardly interrupted stripes on primary puncture-rows, slightly darkened along middle part of suture. Primary punctures dense and moderately strong, about 40 punctures in row 1. Basal 6–8 punctures of row 5 in clear longitudinal impression (Fig. 29). Puncture-row 7+8 not reaching base, but united just behind base. All punctures darkened except parts of row 8+9. Sparse secondary puncture-row along suture. At most some single secondary punctures on intervals. Central base flat to weakly impressed. Completely margined, margin in middle invisible from above.

Underside: Yellow to yellow-red, slightly darker on prosternal and metasternal process. Legs yellow to yellow-red, slightly darkened towards coxae. Elytral epipleura yellow, reaching to middle of sternite 5, with uncoloured punctures, strong dense puncture-row on narrowed posterior part. Prosternum anteriorly clearly margined. Prosternal process nearly parallel, anteriorly wider than posteriorly, in middle strongly impressed in posterior 2/3, anterior edge strongly margined, lateral ridges with groove formed by row of coarse punctures, anterior part densely and coarsely punctured, in posterior impression unpunctured (Figs 31, 32). Metasternal process diverging posteriorly, anteriorly impressed in middle, weakly to moderately strongly punctured, in middle usually slightly hairy, laterally with fine plicae formed by punctures (Fig. 31). Metacoxal lobes not reaching sternite 5, weakly and sparsely punctured near suture, stronger and denser punctured in lateral part. Sternite 4–6 with posterior irregular puncture-row. Last sternite especially on apex stronger punctured. Metatibia without setiferous striole on dorsal face, but posteriorly with kind of fine ridge on inner side, longer tibial spur about as long as first tarsal segment (Fig. 33).

Male: Pro- and mesotarsomeres 1–3 widened, tarsomere 1 more dilated ventrally, only tarsomeres 1+2 with sucker hairs on ventral side. Protarsal claws clearly unequal in length (Fig. 30). Penis and parameres as in Figs 34–36.

Biology
Unknown.

Distribution (Fig. 155).
Only known from North East Queensland.

Haliplus fuscatus Clark
(Figs 37–46)

Haliplus fuscatus Clark, 1862: 401. Holotype ♀, no data [Clark gives Adelaide as locality] (BMNH) [examined].

Haliplus fuscatus; Zimmermann 1920: 308; 1924: 141; Watts 1985: 27, 1988: 27; Lawrence *et al.* 1987: 322.

Remarks
I failed to find reliable characters to distinguish

between females of *H. fuscatus* and *H. gibbus*. As the holotype of *H. fuscatus* is a ♀, I am not sure whether I have correctly associated it with males which are treated here as *H. fuscatus*.

Both species have more or less the same distribution. It is distinctly possible that the holotype of *H.fuscatus* and the lectotype of *H.gibbus* are conspecific, in which case at least the ♂ specimens here treated as *H. fuscatus* should belong to an undescribed species.

Diagnosis

This species is closely related to *H. gibbus* as evidenced by general similarity, although the male has a different penis, which is very narrow in *H. fuscatus*.

Description

Length 2.4–3.2 mm, width 1.2–1.8 mm. Body oval, but parallel to subparallel in middle (Fig. 37).

Head: Yellow-brown to brown-red, sparsely punctured. Antenna yellow, last segment slightly darker (Fig. 38). Palpi yellow to yellow-brown. Distance between eyes about 1.3x width of one eye.

Pronotum: Yellow-brown to brown-red, basally strongly impressed and vaguely darkened between short straight plicae, anteriorly with vague transverse mark. Lateral borders finely margined, hind corners rounded (Fig. 37). Strongly and moderately densely punctured, in basal depression only few sparse punctures.

Elytra: Yellow-brown to brown-red. Vague markings on primary puncture-rows, along suture and usually on intervals in posterior half and along base to puncture-row 4 (Fig. 37). Primary punctures dense and moderately strong, 25–35 punctures in row 1. Basal 4–5 punctures of row 5 not in clear longitudinal impression, but at most a little confluent (Fig. 39). Puncture-row 7+8 not reaching base, but united just behind base. All punctures darkened except parts of row 8+9. Stria (sometimes vague) along anterior 1/3 and posterior 1/5 of suture. Fine secondary punctures along suture and usually very fine punctures on most of intervals. Surface with very fine, hard to recognize micropunctuation in both sexes. Body outline in posterior half a little bulbous and there margin not visible from above. Central base weakly impressed. Completely margined.

Underside: Brown-red, darker on prosternal and metasternal process. Legs yellow-brown, slightly darkened towards coxae. Elytral epipleura yellow, reaching to middle of sternite 5, with uncoloured punctures, only a few punctures on narrowed posterior part, two puncture-rows on anterior part weak and about equal in strength. Prosternum anteriorly clearly margined. Prosternal process parallel, in middle strongly impressed in posterior 3/4, curved anterior edge strongly margined, laterally with narrow groove formed by row of coarse punctures, weakly punctured (Fig. 41, 42). Metasternal process diverging posteriorly, anteriorly impressed in middle, weakly punctured, laterally with fine plicae formed by punctures (Fig. 41). Metacoxal lobes not reaching sternite 5, weakly and sparsely punctured near suture, a little stronger punctured in lateral part. Sternite 4–6 posteriorly with very fine irregular puncture-rows. Last sternite weakly punctured. Metatibia without setiferous striole on dorsal face, longer tibial spur about as long as first tarsal segment.

Male: Pro- and mesotarsomeres 1–3 widened, tarsomere 1 more dilated ventrally, only tarsomeres 1+2 with sucker hairs on ventral side. Protarsal claws equal in length (Fig. 40). Metatarsal claws short and strongly bent. Penis and parameres as in Figs 44–46.

Female: Metatarsal claws long and almost straight.

Biology

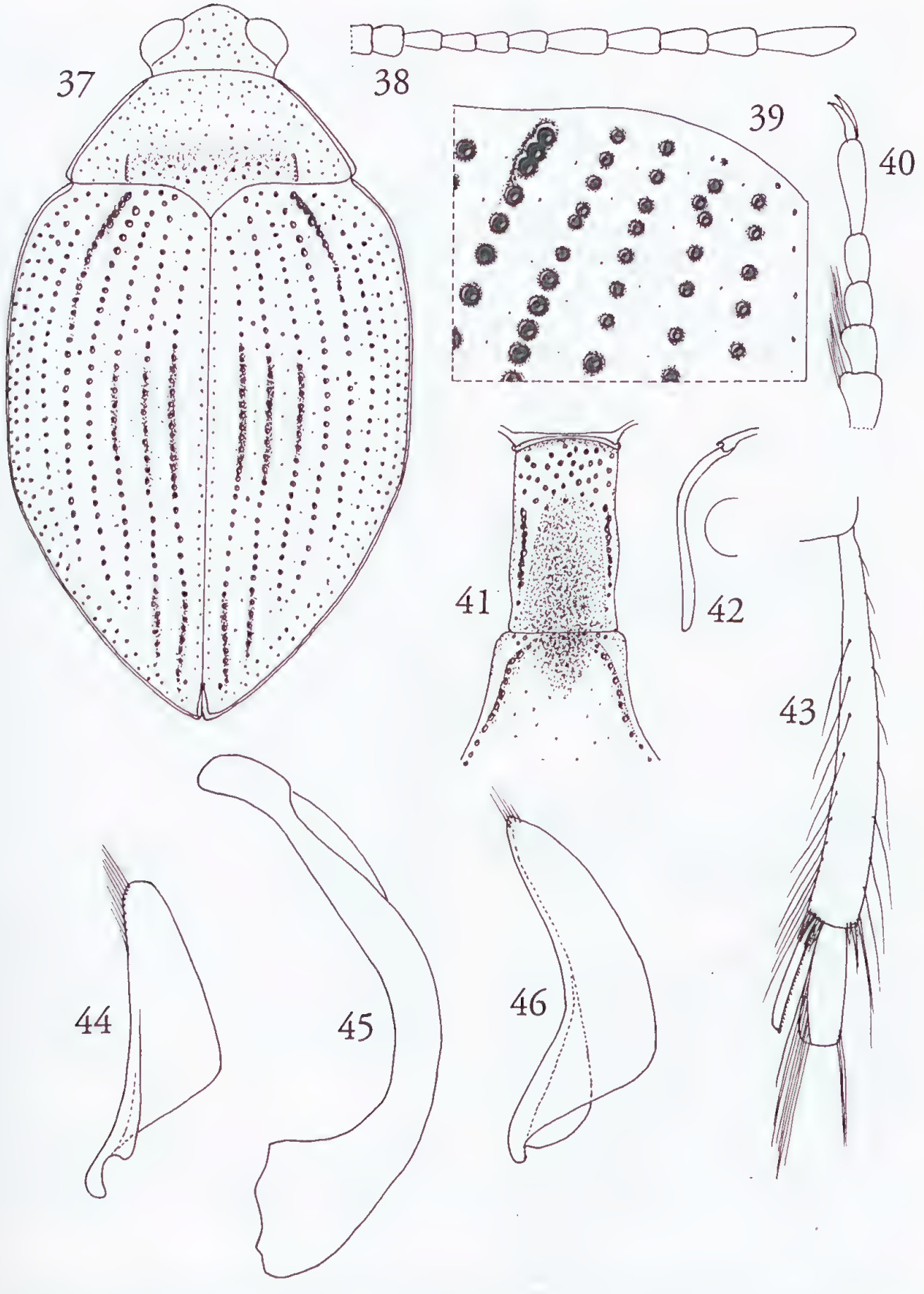
This species occurs in swamps, temporary ponds, rivers and lakes. A specimen was found in a trout stomach. It is attracted to light.

Distribution (Fig. 157)

West Australia, South Australia, Victoria, New South Wales ?(no males known), Queensland.

Material examined (identification based on ♂): Australia: West Australia: 1 ♂, 1 ♀, Bickley Swp, Rottnest Isl., x.1959, D.E. (CW, SAMA); 1 ♂, 1 ♀, Bulldozen, Rottnest Isl., W.A., x.1958, D.E. (CW); 1 ♂, Rottnest Isl., Salmon Swp, x.1958, D.E.; 1 ♀, Rottnest Isl., Barkers Swp, x.1959., D.E. (SAMA); 1 ♀, W.A., Rottnest Isl, x.1931, Harvard Expedition Darlington (MCZC); South Australia: holotype ♀ (BMNH); Victoria: 1 ♂, 5 ♀, Vic. Eildon Weir, ix.1943, F. E. Wilson (5 in MVMA, 1 in CV); 1 ♂, Wyperfield Nat. Park, Lowan Track, 35.35S, 142.05E, light trap, 16.xi.1973. S. Misko, *Haliplus fuscatus* Clark det. T. A. Weir 1987 (ANIC); Queensland: 1 ♂, 4 ♀, C. Qld, L. Galilee, 20.i.1983, Timms (SAMA).

Females of *H. fuscatus* or *H. gibbus* : Australia: South Australia: 1 ♀, Parra Wirra, ix.1969, C.W. (SAMA); Victoria: 1 ♀, Eilham, C. Oke; 1 ♀, Birchip; 2 ♀, Carrum, 29.xii.1920, C. Oke; 1 ♀, Coliban R., Trentham, F. E. Wilson; 1 ♀, E.



FIGURES 37–46. *Haliplus fuscatus*, **37**, Holotype ♀; **38–46**, ♂, Rottnest Island: **37**, dorsal view; **38**, antenna; **39**, punctures near elytral base and suture; **40**, tarsus of male fore-leg; **41**, prosternal and metasternal process; **42**, prosternal process in lateral view; **43**, hind tibia; **44**, left paramere; **45**, penis; **46**, right paramere.

Moorabool R., 4 km W. Ballan, 10.vi.1976, Neboiss; 1 ♀, Howitt coll.; 1 ♀, Clarkfield, 1.ix.1-937, F. E. Wilson (MVMA); 1 ♀, Clarkfield, 4.xi.1941, A. D. Butcher, ex trout stomach (CV); 1 ♀, Dimboola, 36.27S, 142.02E, 22.x.1983, J. C. Cardale, at light (ANIC); 1 ♀, Ringwood, *Haliplus gibbus* Clark, *Haliplus fuscatus* det. C. Watts 84; 1 ♀, *Haliplus gibbus* Clk, Howitt Coll. (MVMA); New South Wales: 1 ♀, Forest Reefs (MCZC); 1 ♀, Bogan R., J. Armstrong (SAMA); 1 ♀, Willanora Bridge, 11 km N. of Mossgiel, 33.16S, 144.34E, dry swamp, 21.xii.1970, at light, Britton, Misko & Pullen (ANIC); 1 ♀, Barrenbox Swamp, interior N.S.W., 24.x.1979, Fields (ZMUC); Federal state unknown: 1 ♀, Sandham, x.1935 (ANIC);

Haliplus gibbus Clark
(Figs 47–56)

Haliplus gibbus Clark, 1862: 400. Lectotype ♂ (designated by Watts, 1988), 'S. Aust., Bakewell 59/24' (BMNH)[examined].

Haliplus gibbus; Zimmermann 1920: 308; 1924: 142; Watts 1985: 27, 1988: 26; Lawrence *et al.* 1987: 322.

Remarks

See remarks under *H. fuscatus*.

Diagnosis

This species closely resembles *H. fuscatus*, from which the male can be distinguished by the penis, which is broader in *H. gibbus*. I am not able to distinguish the females.

Description

Length 2.4–3.2 mm, width 1.2–1.6 mm. Body oval, but parallel to subparallel in middle (Fig. 47).

Head: Yellow to yellow-brown or yellow-red, sparsely punctured. Antenna yellow, last segment darker (Fig. 48). Palpi yellow to yellow-brown. Distance between eyes about 1.3x width of one eye.

Pronotum: Yellow to yellow-brown, strongly impressed base slightly darkened between straight plicae, which are 1/4 to 1/3 of length of pronotum, anteriorly usually slightly darkened. Lateral fine margins narrowed anteriorly, hind corners rounded. Anterior half densely punctured, front and hind corners coarsely punctured, in basal depression row of strong punctures (Fig. 47).

Elytra: Yellow-brown to yellow-red. Dark marks on parts of primary puncture-rows, along suture and along base to puncture-row 5 and on intervals. Primary punctures dense and moderately strong, about 30 punctures in row 1. Basal 3–4 punctures of row 5 in weak longitudinal impression (Fig. 49). Puncture-row 7+8 not reaching base, but united just behind base. All punctures darkened except parts of row 8+9. Stria along apical part of suture, sparse row of weak secondary punctures along suture. No discernible secondary punctures on intervals, except a few large ones. Central base flat to weakly impressed. Completely margined.

Underside: Yellow to yellow-red, slightly darker on prosternal and metasternal process. Legs yellow to yellow-red, slightly darkened towards coxae. Elytral epipleura yellow, reaching to middle of sternite 5, with uncoloured punctures. Prosternum anteriorly clearly margined. Prosternal process parallel, in middle strongly impressed in posterior 2/3, anterior edge strongly margined, laterally with groove formed by row of coarse punctures, anterior part densely and coarsely punctured, in posterior impression only weakly punctured (Fig. 49). Metasternal process diverging posteriorly, anteriorly impressed in middle, moderately strongly punctured, laterally with plicae formed by punctures (Figs 51, 52). Metacoxal lobes not reaching sternite 5, weakly and sparsely punctured near suture, stronger and denser punctured in lateral part. Sternite 4–6 at most with a few very fine punctures. Last sternite with only a few very fine punctures, very short fine keel on apical point. Metatibia without setiferous striole on dorsal face, longer tibial spur about as long as first tarsal segment (Fig. 53).

Male: Pro- and mesotarsomeres 1–3 widened, tarsomere 1 more dilated ventrally, only tarsomeres 1+2 with sucker hairs on ventral side. Protarsal claws equal in length (Fig. 50), metatarsal claws short and strongly curved. Penis and parameres as in Figs 54–56.

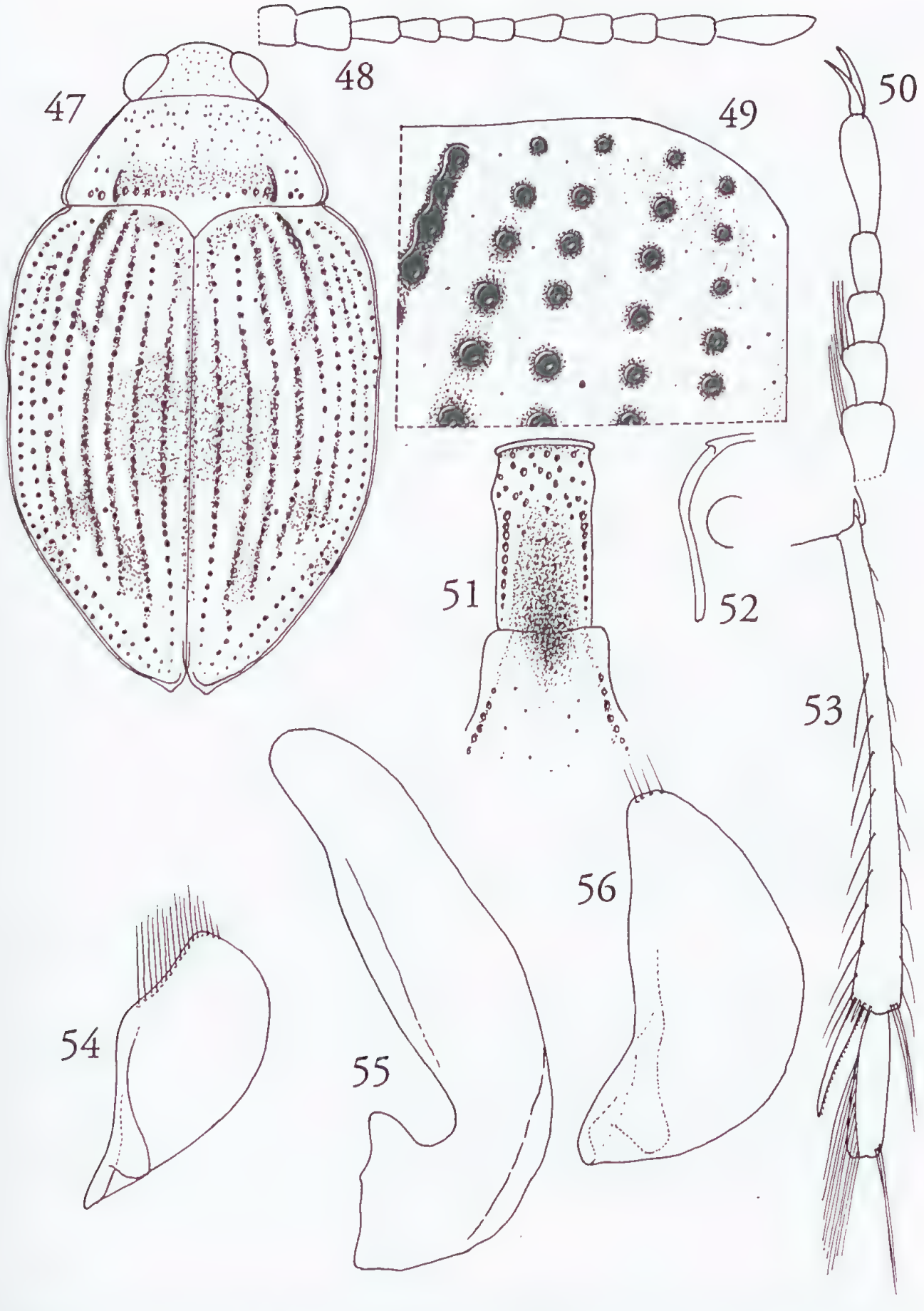
Female: Metatarsal claws long and hardly curved.

Biology

This species occurs in swamps, temporary ponds and rivers and has been collected from submerged vegetation at the margin of slow moving streams (Watts, pers. comm.).

Distribution (Fig. 158)

Western Australia, South Australia, Victoria, Tasmania, New South Wales ? (no males known from this state).



FIGURES 47–56. *Haliplus gibbus*, Lectotype ♂: **47** dorsal view; **48**, antenna; **49**, punctures near elytral base and suture; **50**, tarsus of male fore-leg; **51**, prosternal and metasternal process; **52**, prosternal process in lateral view; **53**, hind tibia; **54**, left paramere; **55**, penis; **56**, right paramere.

Material examined (identification based on ♂): Australia: West Australia: 1 ♂, Armadale, vii.1960. D.E. (SAMA); 2 ♂, 1 ♀, Picton Junction, Swamp near Ferguson R., 30.xi.1965, Britton & Uther Baker (2 in ANIC, 1 in CV); 1 ♂, 7 km E. of Wuranga, xi.1981, K. & E. Carnaby (ANIC); 1 ♂, Bridgetown, 8.xi.1931, Australia Harvard Expedition, Darlington (MCZC); South Australia: lectotype ♂ (BMNH); 2 ♂, 2 ♀, Williamstown, ix.1961. C. Watts (SAMA); Victoria: 2 ♂, E. Pomborneit, 24 km ESE Camperdown, temporary pond, viii.1978–ii.1979, P. S. Lake (ANIC); 1 ♂, 1 ♀, E. Vic., Yarra Riv., Warburton, F. E. Wilson; 2 ♂, 1 ♀, Newhill Res., x.1945, F. E. Wilson (MVMA); Tasmania: 1 ♂, 2 ♀, Launceston, 8.vi.1948 (ANIC); 1 ♂, Launceston (QMBA); 2 ♂, Launceston; 1 ♂, 3 ♀ (MVMA); 1 ♂, 1 ♀, Launceston (ISNB); Federal state unknown: 3 ♀ syntypes (BMNH); 4 ♂ [no locality] (MVMA); 1 ♂, 1 ♀, Sandham, Goudie [?], x.1935 (MVMA, CV).

Haliplus bistriatus Wehncke
(Figs 57–69)

Haliplus bistriatus Wehncke, 1880: 75. Type-material: Not located. In the Wehncke collection in MNHN one ♂ is present originating from Brisbane. In the description, however, Adelaide is mentioned as type-locality.

Haliplus bistriatus sensu Fauvel 1883, nec Wehncke 1880. [Misidentification].

Haliplus bistriatus; Fauvel 1883: 335; Zimmermann 1920: 304; 1924: 71; Guignot 1935a: 36; 1935b: 164; Watts 1985: 27, 1988: 25; Lawrence *et al.* 1987: 322.

Diagnosis

This species can be distinguished from *H. fuscatus* and *H. gibbus* by the long curved pronotal plicae, from *H. hydei* by the basally curved pronotal plicae and the metasternal process not covered with dense hairy punctures and from *H. oberthuri* and *H. storeyi* by the smooth last sternite. Most males can be distinguished from those of related species by the solid digitus on top of the left paramere.

Description

Length 2.5–3.4 mm, width 1.2–1.6 mm. Body oval, parallel to subparallel in middle (Fig. 57).

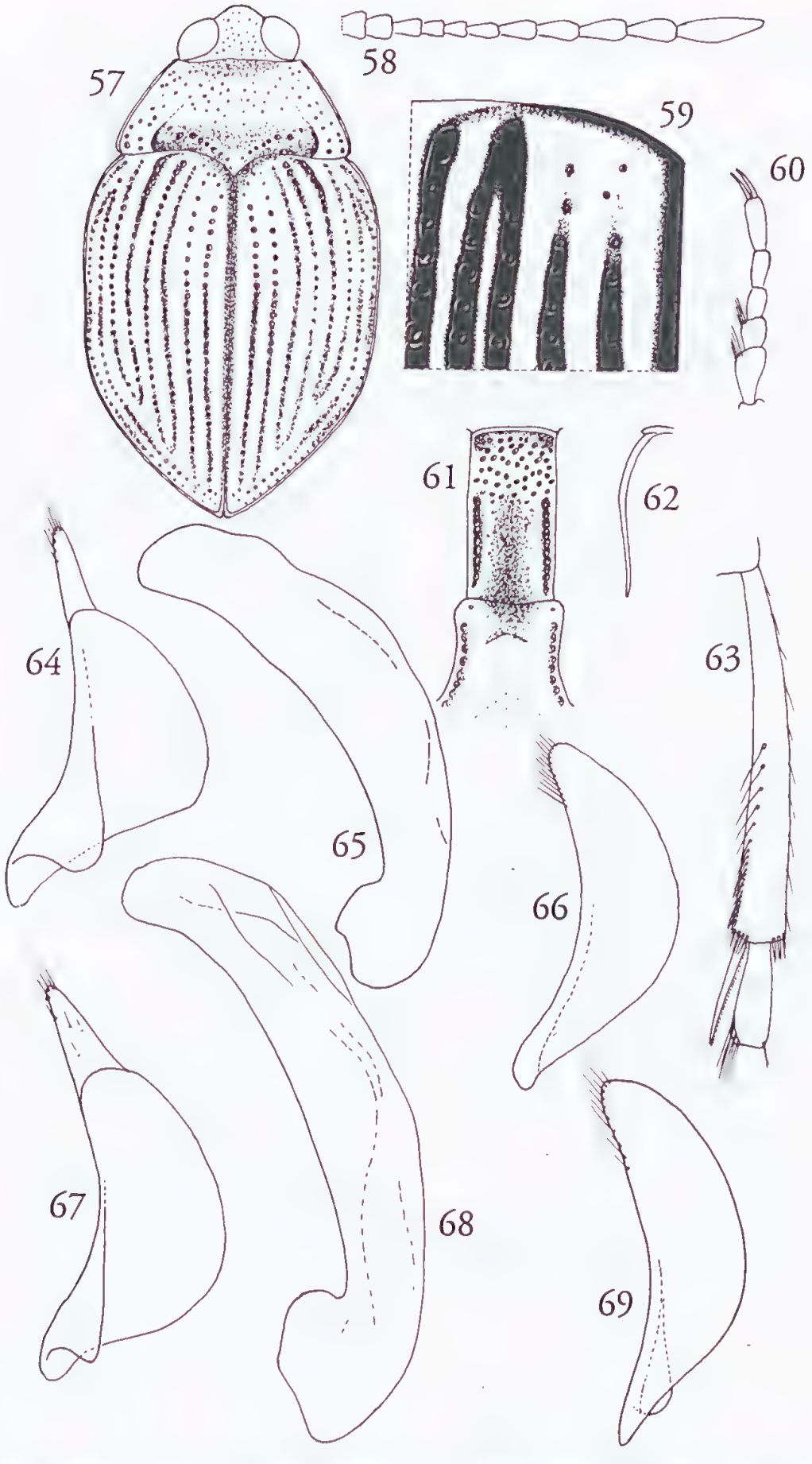
Head: Yellow to yellow-brown or yellow-red, sparsely punctured. Antenna yellow, last segment darker (Fig. 58). Palpi yellow to yellow-brown. Distance between eyes about 1.2x width of one eye.

Pronotum: Yellow to yellow-brown, strongly impressed base narrowly darkened between long curved plicae, anteriorly with dark central mark. Lateral borders finely margined, hind corners rounded. Anterior half densely punctured, front and hind corners coarsely punctured, in basal depression only a few sparse punctures (Fig. 57).

Elytra: Yellow-brown to yellow-red. Dark interrupted stripes on primary puncture-rows, darkened along suture and along base to puncture-row 5. Primary punctures dense and moderately strong, about 35 punctures in row 1. Basal 6–8 punctures of row 5 in clear longitudinal impression. Puncture-row 7+8 not reaching base, but united just behind base. All punctures darkened except parts of row 8+9. Stria along anterior 1/3 and posterior 1/5 of suture. No discernible secondary punctures on intervals. Central base flat to weakly impressed. Completely margined.

Underside: Yellow to yellow-red, slightly darker on prosternal and metasternal process. Legs yellow to yellow-red, slightly darkened towards coxae. Elytral epipleura yellow, reaching to middle of sternite 5, with uncoloured punctures, strong dense puncture-row on narrowed posterior part. Prosternum anteriorly clearly margined. Prosternal process parallel, in middle strongly impressed in posterior 2/3, anterior edge strongly margined, laterally with groove formed by row of coarse punctures, anterior part densely and coarsely punctured, in posterior impression only weakly punctured (Figs 61, 62). Metasternal process diverging posteriorly, anteriorly impressed in middle, moderately strongly punctured, laterally with fine plicae formed by punctures, longitudinal and oblique backwards directed sutural lines visible in middle (Fig. 61). Metacoxal lobes not reaching sternite 5, weakly and sparsely punctured near suture, stronger and denser punctured in lateral part. Sternite 4–6 with posteriorly irregular puncture-row. Last sternite especially on apex stronger punctured. Metatibia without setiferous striole on dorsal face, but posteriorly with kind of fine ridge on inner side, longer tibial spur about as long as first tarsal segment (Fig. 63).

Male: Pro- and mesotarsomeres 1–3 widened, tarsomere 1 more dilated ventrally, only tarsomeres 1+2 with sucker hairs on ventral side. Protarsal claws equal in length (Fig. 60). Penis and parameres as in Figs 64–69. Left paramere with solid digitus (Fig. 64 or 67).



FIGURES 57–69. *Haliplus bistriatus*, **57–66**, Brisbane; **67–69**, Mt Mulligan: **57**, dorsal view; **58**, antenna; **59**, punctures near elytral base and suture; **60**, tarsus of male fore-leg; **61**, prosternal and metasternal process; **62**, prosternal process in lateral view; **63**, hind tibia; **64**, left paramere; **65**, penis; **66**, right paramere; **67**, left paramere; **68**, penis; **69**, right paramere.

Biology

Specimens have been attracted to light in places in open forest.

Distribution (Fig. 154).

Queensland and northern part of Western Australia.

Material examined: Australia: Queensland: 1 ♂, Brisbane, Sharp, Dr Guignot visit 1939 (MNHN); 2 ♂, Caloundra, Qld, 24.iii.1963, C. Watts (CW); 2 ♀, unlabelled (QMBA); 2 ♀, Bne [Brisbane?], *H. testudo* Clark, *Haliplus stepheni ms.nom* det C.Watts 84 (QMBA, CV); 1 ♂, 1 ♀, N. Qld, 21 E. Mareeba, 21.i.1991, at light, R. I. Storey (QPI, CV); 1 ♀, Brisb[ane], Howitt Coll.; 1 ♂, unlabelled, Howitt Coll. (MVMA); 1 ♂, NQ., Mt Spec., ii.1971, J. G. Brooks, *Haliplus stepheni ms.nom.* det. C. Watts 84 (ANIC); 2 ♂, 5 ♀, nr Mt Mulligan, 31.i.1991, Larson & Halfpap (MUNC); Western Australia: 1 ♀, CALM Site 13/4, 12 km S. of Kakumburu Mission, 14.25S, 126.38E, 7–11.vi.1988, T. A. Weir, at light, in open forest (ANIC).

Haliplus australis Clark
(Figs 70–78)

Haliplus australis Clark, 1862: 400. Lectotype ♀ (designated by Watts, 1988), *H. australis* Clark [yellow label], B.M., Type [white round label with red margin], Lectotype [white round label with blue margin], LECTOTYPE Female, *Haliplus australis* Clark 1862, selected by C. Watts, 1984. (BMNH)[examined].

Haliplus australis; Zimmermann 1920: 303; 1924: 141; Watts 1985: 27, 1988: 23; Lawrence *et al.* 1987: 322.

Haliplus testudo; Watts 1985: 27, 1988: 23.

Remarks

Watts (1988) considered this species to be a junior synonym of *H. testudo*. After examination of type material of both names I regard them as separate species.

Diagnosis

Males of *H. australis* have a solid digitus on the apex of the left paramere, while *H.testudo* lacks such a digitus. The penis of *H. testudo* is more curved towards the tip. The elytra of *H. australis* usually have no dark stripes on puncture-rows, while *H. testudo* have well developed dark stripes on elytral puncture-rows.

Description

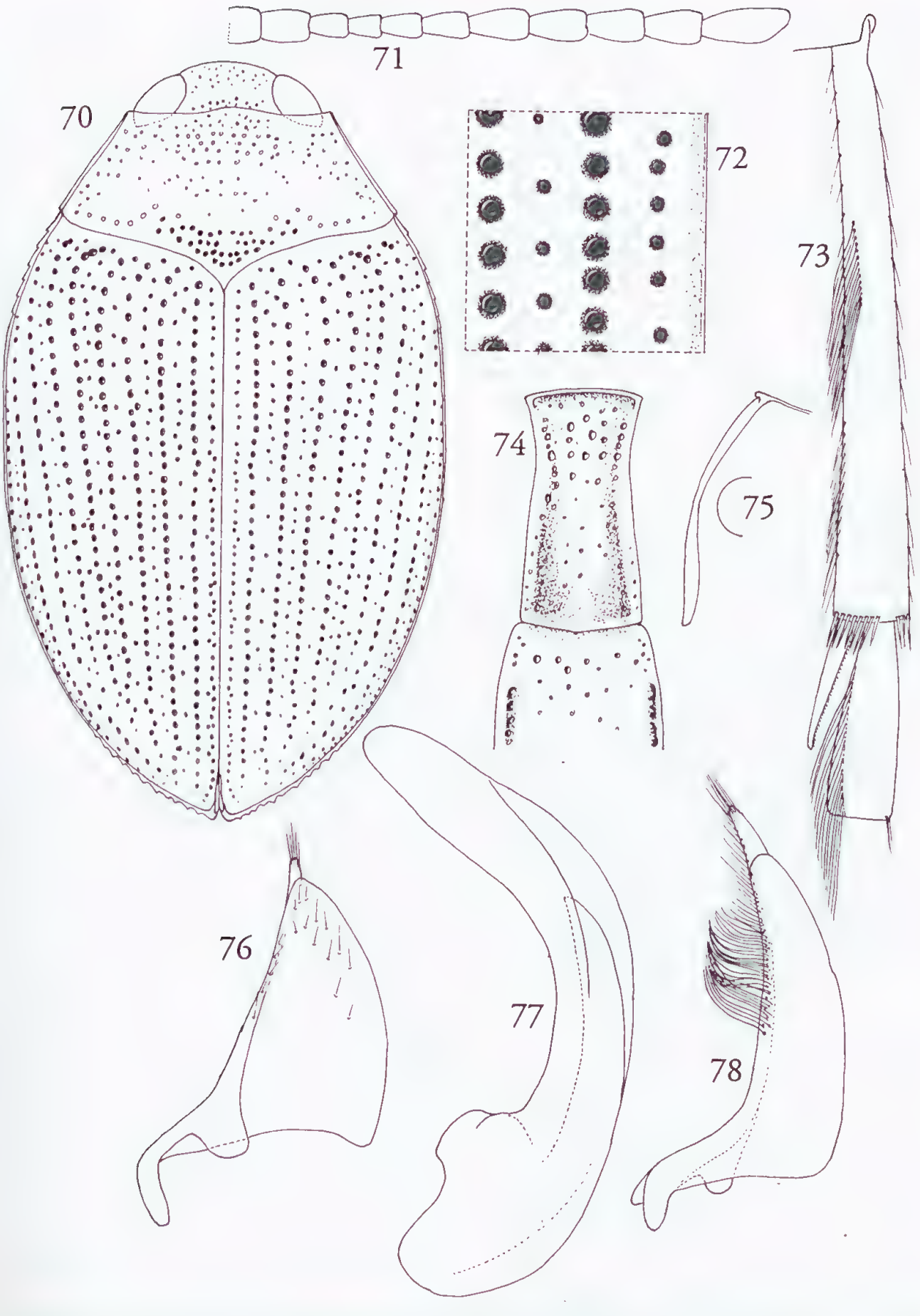
Length 3.7–4.1 mm, width 2.1–2.3 mm. Body wide oval, widest just in front of middle (Fig. 70).

Head: Yellow to yellow-brown, vertex slightly darker, weakly and sparsely punctured, on vertex a little stronger punctured. Antenna yellow (Fig. 71). Palpi yellow, last segment small, 1/3x length of penultimate segment. Clypeus finely margined anteriorly. Distance between eyes 1.3–1.6x width of one eye. Eyes usually partly covered by pronotum.

Pronotum: Yellow to yellow-brown, moderately strongly and densely punctured along base and in middle of anterior part, otherwise weaker and sparser punctured, punctures in central part of base and anterior part darkened. Punctures not stronger than elytral punctures. Anterior margin a little protruding between eyes, posterior margin slightly impressed in middle. Lateral borders straight, finely margined.

Elytra: Yellow without maculation, only suture narrowly brown, punctures darkened but darkening rarely forming continous lines. Primary punctures strong and dense, about 48 punctures in row 1. All punctures with clear hole in middle. Puncture-row 1–7 not much differing in strength, row 8 clearly weaker, row 9+10 very weak and hardly darkened. Distance between row 10 and 9 and between row 9 and 8 clearly more than between row 8 and 7. First three basal punctures of row 5 confluent. Secondary punctures strong, dense and partly doubled in sutural row on interval 1, dense in interval 2, 3, 5 and 7, less dense in interval 4, in interval 6+8 only a few punctures in basal and posterior part, in posterior part of interval 9 continous dense row of weak punctures, in row 10 a few weak punctures in central part. Completely margined, anteriorly with about seven very weak flat teeth, in apical part with about twelve small sharp teeth.

Underside: Yellow to yellow-brown, elytral epipleura yellow with uncoloured punctures. Legs yellow to yellow-brown, slightly darkened towards coxae. Prosternal process parrallel-sided, slightly narrowed in central part, along both margins impressed in posterior half, anterior edge clearly margined, strongly punctured along margins and with a few punctures in middle part (Figs 74, 75). Prosternum strongly punctured and anteriorly finely margined. Proepisternum at most weakly punctured in anterior part. Metasternal process flat in middle, strong punctures on both sides partially confluent, more or less forming short impressions, which do not reach anterior margin, otherwise weakly punctured (Fig. 74). Metacoxal lobes fairly



FIGURES 70–78. *Haliplus australis*, **70–75**, Lectotype ♀; **76–78**, Paralectotype ♂: **70**, dorsal view; **71**, antenna; **72**, punctures near elytral base and suture; **73**, hind tibia; **74**, prosternal and metasternal process; **75**, prosternal process in lateral view; **76**, left paramere; **77**, penis; **78**, right paramere.

strongly punctured, in sutural area weaker punctured. Outer protarsal claws of males seem to have tooth on inner margin. Setiferous striole on dorsal face of hind tibia about 1/8x length of tibia (hard to see), it looks like there is on inner margin another setiferous striole over apical half, longer tibial spur about 2/3x length of first tarsal segment (Fig. 73).

Male: Pro- and mesotarsomeres 1–3 widened and with sucker hairs on ventral side. Penis and parameres as in Figs 76–78. Left paramere with small solid digitus (Fig. 76).

Biology

Specimens occur in rivers and ponds and have been found in trout stomachs. Watts (pers. comm.) found specimens in a well shaded woodland pond that dries out completely in summer.

Distribution (Fig. 159)

Australia: South Australia, Victoria, Queensland.

Material examined: Australia: Federal state unknown: Lectotype ♀ (BMNH); 2 ♂, 3 ♀, Howitt coll. (MVMA); Queensland: 1 ♀, 1 ♂, Glen Valley, ii.1951, VI-, F. E. Wilson (CW); South Australia: 2 ♂ syntypes, S. Australia, S.s., 67–56, *H. australis* Clark, Australia (BMNH); 1 ♂, 2 ♀, Chain of Ponds, 4.xii.1989, C.W. (CW); 1 ♂, Cheltenham, 20.iii.1925 (MVMA); Victoria: 1 ex., Flowerdale, 22.i.1968, R. E. Parrott (CNCI); 2 ♂, Jamieson, 20.iv.1943, F. E. Wilson; 1 ♀, Yarra Riv., Melgrove, 4.i.1952, F. E. Wilson; 2 ♂, 6 ♀, Glenmaggie, Weir, iv.1957, F. E. Wilson; 1 ♂, 1 ♀, Lake Wendourec, ii.1945, F. E. Wilson; 2 ♂, Eildon Weir, ix.1943, F. E. Wilson; 1 ♂, Melbourne, Howitt coll. (MVMA); 1 ♂, Clarkfield, 31.x.1942, A. D. Butcher, Ex trout stomach (CV); 1 ♂, E. Vic., Cann Riv., 28.i.196-7, G. Monteith (UQIC).

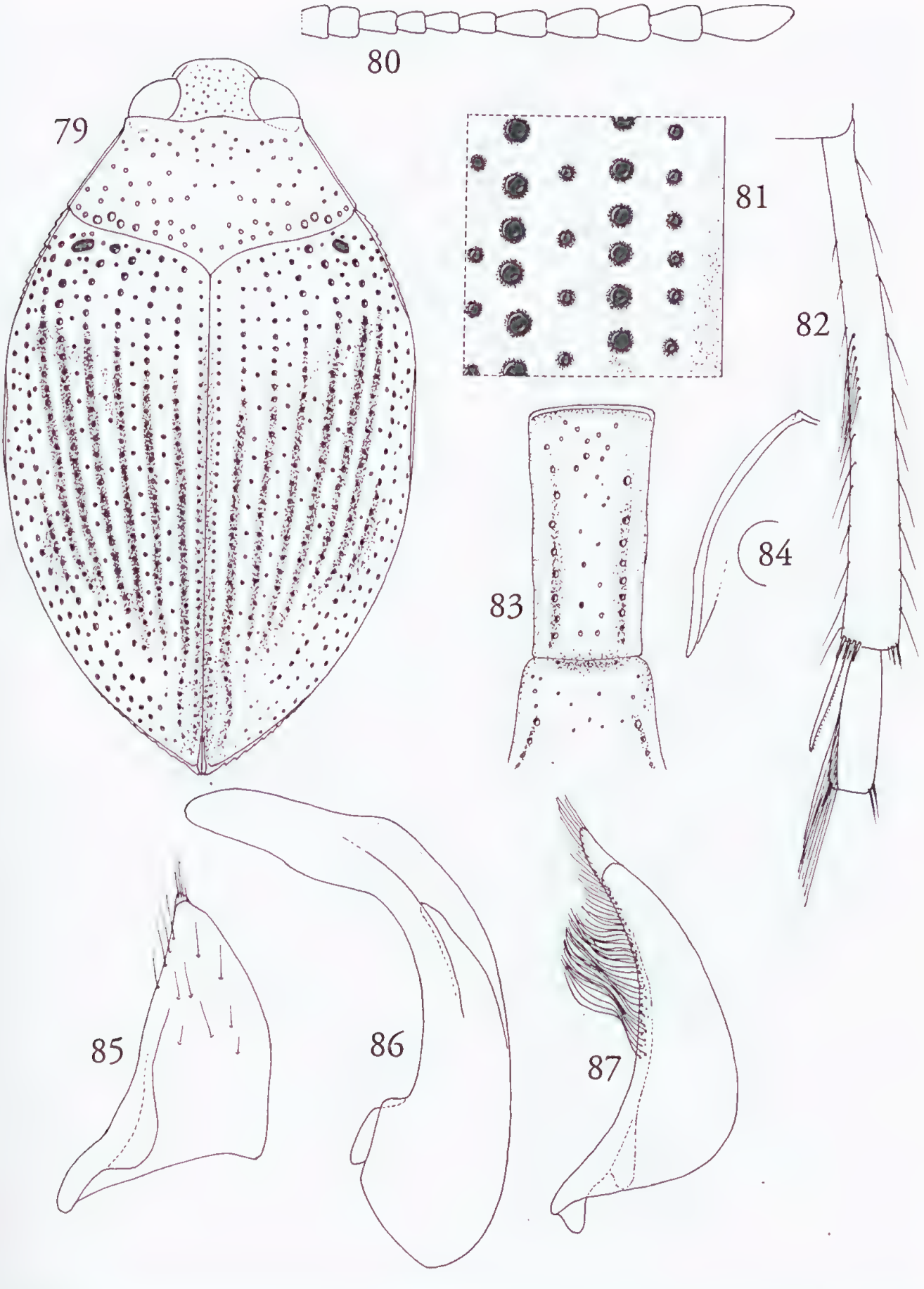
Haliplus wattsi sp.n.

(Fig. 79–87)

Type-material: ♂ holotype, 'Homehill, Qld, 7.iv.1963, CW.' (CW). Paratypes: 1 ♂ and 1 ♀, on same pin as holotype; 2 ♂, same data as holotype (CW, CV); 1 ♂, Bandenberg, Queensland, 31.iii.1963, CW, *H. testudo* det. C. Watts, 1991; 1 ♂, 25 km. N. Coen, Queensland, 29.ix.1984, C. Watts (CW); 1 ♂, Australia, N. Q., Koombaloomba, 10.i.1962, E. B. Britton, B.M. 1962–153, At light (BMNH); 1 ♂, Nov. Holl.d., Rockkompt [?], Daniel (MNHN); 1 ♀, unlabelled, T12706; 1 ♂, Tambourine Mountain, Jan. 1898, C.J. Wild, *Haliplus alastairi* ms.nom. det C. Watts, T12707 (QMBA); 1 ♀, S.E. Qld, Atkinson's Lagoon, 13 km N.W. Lowood, 10.ix.1978. J. King, *Haliplus testudo* Clark det. C. Watts 1987; 1 ♂, 1 ♀, N. Qld, Mc Ivor River, 40 ml. N. of Cooktown, 7.v.1970, G. B. Monteith, *Haliplus testudo* Clark, det. C. Watts 1987 (UQIC); 1 ♀, N. Qld, Iron Range, Cape York Pen., 28.iv–1.v.1968, G. B. Monteith, *Haliplus testudo* Clark, det C. Watts 1987 (CV); 1 ♀, N. Qld, Homestead, Silver Plains, Via Coen, 11.xii.1964, G. B. Monteith, *Haliplus testudo* Clark Det. C. Watts 1987 (UQIC); 1 ♂, 2 ♀, N. W.A., Kununurra, 22.xii.1991–6.i.1992, R. I. Storey; 1 ♂, 4 ♀, N. Qld, 10 km S. of Laura, 4.iii.1992, at light, J. Hasenpusch; 1 ♀, N. Qld, Tolga, 27.i.1987, J.D. Brown, light trap, *Haliplus testudo* Clark, det. C. Watts 1987; 1 ♂, Qld, 21 km S. Mareeba, 22.i.1991, R. I. Storey; 1 ♂, N. Qld, Cow Bay, N. of Daintree, 25.i–7.ii.1984, I.C. Cunningham, *H.testudo* C. Watts det. 1987; 1 ♂, N. Qld, 7 km NE of Tolga, Feb. 1988, Storey & De Faveri, light trap, *Haliplus testudo* Clark det. C. Watts 1988; 1 ♂, N. Qld, 7 km NE of Tolga, MAR. 1987, Storey & De Faveri, light trap, *H.testudo* Clark det C. Watts 1987; 2 ♂, 2 ♀, N.T., 6 km E. Humpty Doo, 9.ii–4.iii.1987, R. I. Storey (QPI); 1 ♂, Papua, Loloki, c. 10 m. N. of Pt. Moresby, 19.iii.1965, Stn No. 205, M. E. Bacchus, B.M. 1965–120 (BMNH); 1 ♀, Cardstone, Qld, 17–23.ii.1966, K. Hyde, *Haliplus testudo* Clk det. C. Watts; 1 ♀, S. of Charleville, Q., 9.v.1973, M.S. Upton, *Haliplus testudo* Clk det. C. Watts; 1 ♂, Katharine N.T., at light, 9.ii.1968, J. A. L. Watson, *Haliplus testudo* Clk det. C. Watts; 1 ♂, Coastal Plain Rsch. Station, C.S.I.R.O. nr Darwin, N.T., at light, ix.1966, E. C. B. Langfield (ANIC); 1 ♂, Cahills Crossing, N.T., East Alligator River, 12.26S, 132.58E, 2.v.1973, E.G. Matthews, at light, *Haliplus ?australis* Clark, det T. A. Weir, 1980, *Haliplus testudo* Clk det. C. Watts; 1 ♂, N.T., 6 km E. Humpty Doo, 9.ii–4.iii.1987, R. I. Storey; 1 ♀, N. Qld, 7 km NE of Tolga, Feb. 1988, Storey & De Faveri, light trap, *Haliplus testudo* Clark det. C. Watts 1988; 1 ♂, N. Qld, 10 km S. of Laura, 4.iii.1992, at light, J. Hasenpusch; 1 ♂, N. W.A., Kununurra, 22.xii.1991–6.i.1992, R. I. Storey (CV); 1 ♀, Queensland, 160 km S. of Cooktown, 500 m, 28.i.1964, J. Sedlacek (BPBM); 1 ♂, 1 ♀, Qld, Port Douglas, 8.i.1991, D. Larson; 2 ♂, Qld, 5 km S. of Mareeba, 15.i.1991, Larson (MUNC).

Diagnosis

This species can easily be distinguished from



FIGURES 79–87. *Haliplus wattsi*, Holotype ♂: **79**, dorsal view; **80**, antenna; **81**, punctures near elytral base and suture; **82**, hind tibia; **83**, prosternal and metasternal process; **84**, prosternal process in lateral view; **85**, left paramere; **86**, penis; **87**, right paramere.

H. australis and *H. testudo* by the proepisternum being strongly and densely or even coarsely punctured. It can also be distinguished from *H. testudo* by the absence of dark stripes on the basal area of the elytra, the prosternal process usually being wider anteriorly than posteriorly, the uncoloured pronotal anterior punctures, the weakly serrate or nearly smooth apical elytral margin and in the male the penis not being gradually curved to the top and the left paramere having a solid, sometimes very small, digitus.

Description

Length 3.4–3.6, width 1.9–2.1 mm. Body oval, widest behind shoulders, strongly tapering behind middle (Fig. 79).

Head: Yellow-red, darkened near antennae, moderately strongly punctured. Antenna yellow to yellow-red, first two segments brown (Fig. 80). Palpi yellow-brown, last segment twice as long as penultimate segment. Distance between eyes 1.3–1.5x width of one eye. Eyes partly covered by pronotum.

Pronotum: Yellow to yellow-red, moderately densely and strongly punctured, base with a few stronger punctures opposite elytral puncture-row 5. Lateral border straight, finely margined, margin not reaching front corner. Base a little impressed opposite elytral puncture-row 3–5.

Elytra: Yellow to yellow-red, suture and puncture-rows darkened in posterior 2/3, sometimes connected by vague marks. Primary puncture-rows dense and moderately strong, 35–40 punctures in row 1, anterior part of first 2 rows weaker, basal 2 or 3 punctures of row 5 usually wide and confluent. Row 9 very dense and impressed in middle. Secondary punctures along suture relatively strong and as dense as primary punctures, sparser but still strong on intervals, except on hardly punctured or unpunctured interval 6+8. All punctures darkened, except some in lateral rows, and with hole in middle. Complete margin not always visible from above, anteriorly serrate, posteriorly weakly serrate or sinuate.

Underside: Yellow-red to yellow-brown, some darkening near prosternal and metasternal process. Elytral epipleura yellow, almost reaching last sternite, with strong weakly darkened punctures. Legs yellow-red, femur and coxa brown to dark-brown. Prosternum margined anteriorly, strongly and densely punctured. Proepisternum strongly and densely or even coarsely punctured. Prosternal process slightly to clearly gradually diverging anteriorly, laterally grooved in especially posterior half, anterior edge clearly margined, moderately strongly punctured (Figs 83, 84). Metasternal process flat to slightly elevated in middle, weakly punctured, laterally with a few confluent punctures (Fig. 83). Metacoxal lobes not reaching sternite 5, moderately strongly, near suture weaker punctured. Sternites strongly punctured, last sternite with very short fine ridge on apical point. Setiferous striole on dorsal face of hind tibia about 1/6x length of tibia, longer tibial spur about 3/4x length of first tarsal segment (Fig. 82), claws at most 1/2x length of last tarsal segment.

Male: Pro- and mesotarsomeres 1–3 slightly widened and with sucker hairs on ventral side. Penis and parameres as in Figs 85–87. Left paramere with small solid digitus (Fig. 85). Penis dorsally dilated (Fig. 86).

Biology

Specimens have been found in rivers and are attracted to light.

Distribution (Fig. 161).

Australia: Queensland, Northern Territory, northern part of Western Australia. Papua New Guinea.

Haliplus testudo Clark
(Figs 88–96)

Haliplus testudo Clark, 1862: 400. Lectotype ♀ (designated by Watts, 1988), 'lectotype [white round label with blue margin], type [white round label with red margin], 67–56, *H. testudo* Clark, Australia, Lectotype female, *Haliplus testudo* Clark, 1862, selected by C. Watts 1984'. [2 ♀♀ on card, right one marked as type]. (BMNH)[examined].

Haliplus australis sensu Watts 1985, nec Clark 1862. [Misidentification]

Haliplus nigrolineatus Wehncke 1883: 145. **syn.n.**

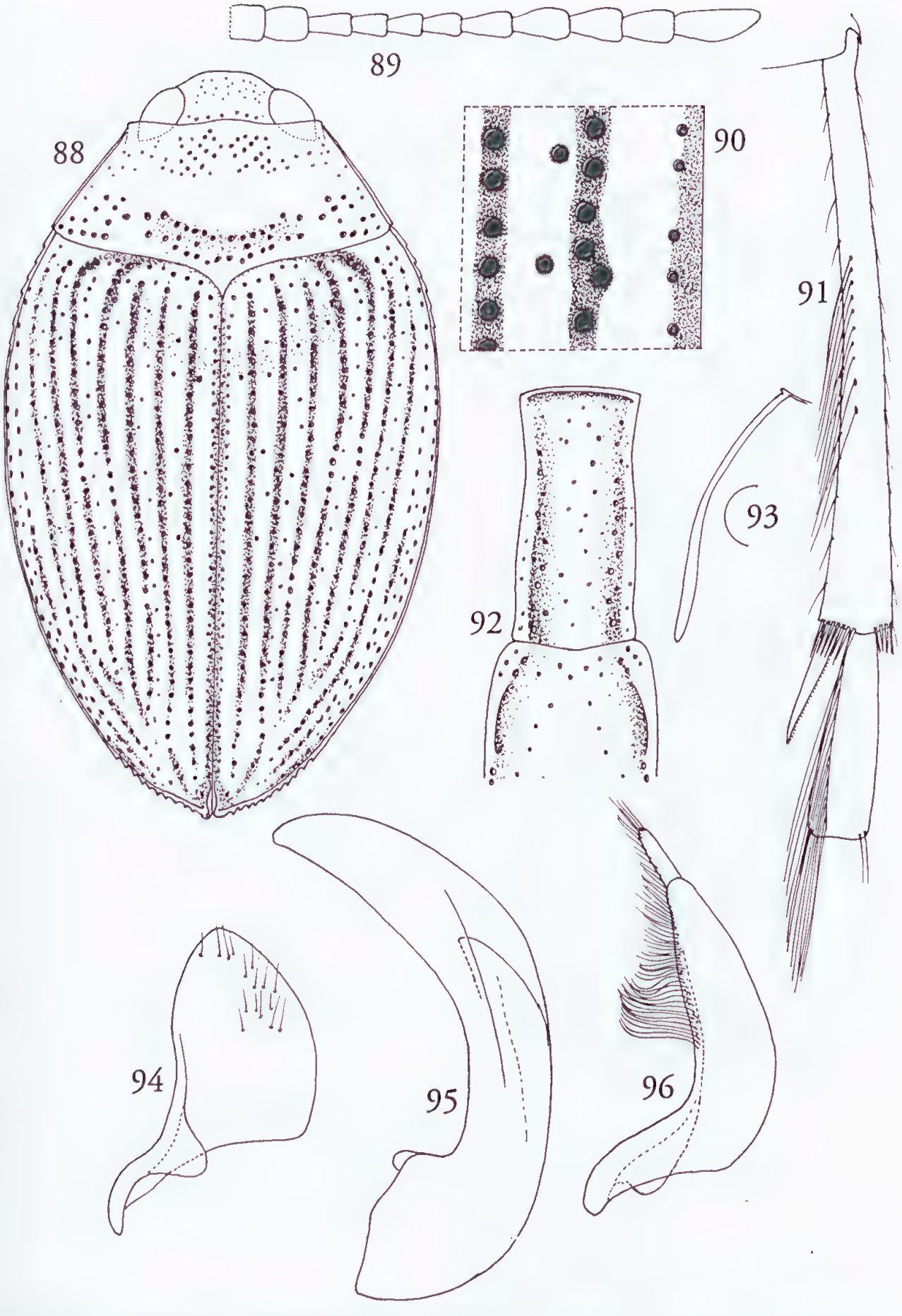
Haliplus testudo; Zimmermann 1920: 316, 1924: 141; Watts 1985: 27, 1988: 23; Lawrence *et al.* 1987: 322.

Haliplus australis; Watts 1985: 27, 1988: 23.

Remarks

Watts (1988) regarded this species as a senior synonym of *H. australis*. I consider the two species to be distinct, because of morphological differences in penis and left paramere (see also remarks under *H. australis*).

In the course of my study of the Neotropical



FIGURES 88–96. *Haliplus testudo*, **88–93**, Lectotype ♀; **94–96**, Sydney: **88**, dorsal view; **89**, antenna; **90**, punctures near elytral base and suture; **91**, hind tibia; **92**, prosternal and metasternal process; **93**, prosternal process in lateral view; **94**, left paramere; **95**, penis; **96**, right paramere.

Haliplidae I examined a syntype of *Haliplus nigrolineatus* Wehncke from Uruguay and concluded that it is conspecific with *H. testudo*. This is obviously a case of mislabelling (further treatment in the revision of the Neotropical Haliplidae)

Diagnosis

This species can be distinguished from *H. australis* by the presence of dark stripes on the basal area of the elytra, the prosternal process usually not being wider anteriorly than posteriorly, the coloured pronotal anterior punctures, the clearly serrate apical elytral margin and in the male the penis being gradually curved to the top and the left paramere not having a solid digitus. It can distinguished from *H. wattsi* by the proepisternum being hardly punctured.

Description

Length 3.5–4.0 mm, width 1.9–2.2 mm. Body oval, widest just in front of middle (Fig. 88).

Head: Yellow to yellow-brown, weakly punctured, on vertex stronger punctured, clypeus not margined anteriorly. Antenna yellow to yellow-brown (Fig. 89). Palpi yellow to brown, last segment 1/3x length of penultimate segment. Distance between eyes 1.5–1.7x width of one eye. Eyes partly covered by pronotum

Pronotum: Yellow-brown, strongly punctured in central anterior area, along base and near lateral margins; transverse area in middle almost unpunctured, most punctures darkened. Lateral borders slightly convex, finely margined. Slight or no impression in front of base.

Elytra: Yellow-brown, black lines on primary puncture-rows continous or sometimes weakly interrupted. Suture darkened, most of base narrowly darkened to puncture-row 5 or 6. Primary punctures moderately strong and dense, about 35 punctures in row 1. Interval 9+10 not much wider than interval 8. Puncture-row 9+10 with separated black punctures except in apical part where short lines may be present. First three or four basal punctures of row 5 confluent. Secondary punctures moderately strong, sometimes as strong as primary ones, sutural row continuous with about 40–45 punctures, 7–10 punctures in interval 2, about 16 in interval 3, interval 4 with only about 4 punctures near base; interval 5,7+9 with sparse row, interval 6,8+10 at most with some punctures in basal area. Completely margined. Shoulders weakly serrate, apical part with about 14 short teeth.

Under side: Yellow-red to yellow-brown, legs yellow-brown to brown, darkened near coxae. Elytral epipleura yellow, reaching to sternite 7. Prosternum margined anteriorly, sparsely punctured. Prosternal process parallel, hardly narrowed near coxae, on both sides with strong groove over almost its total length formed by strong punctures, anterior margin with clear ridge, elsewhere weakly and very sparsely punctured (Figs 92, 93). Metasternal process flat, on both sides an almost continous groove formed by strong punctures, elsewhere weakly and sparsely punctured (Fig. 92). Metacoxal lobes strongly and not very densely punctured, near suture weaker punctured. Setiferous striole on dorsal face of hind tibia weak, about 1/5x length of tibia, longer tibial spur 1/2–2/3x length of first tarsal segment (Fig. 91).

Male: Pro- and mesotarsomeres 1–3 widened and with sucker hairs on ventral side. Penis and parameres as in Figs 94–96. Left paramere without solid digitus (Fig. 94).

Biology

This species is found in rivers and in lentic fresh water and is attracted to light.

Distribution (Fig. 160)

Australia: South Australia, Victoria, New South Wales, Queensland, Northern Territory. The specimen I have seen from Sumatra is obviously mislabelled.

Material examined: South Australia: 1 ♂, 1 ♀ (ANIC); 2 ♂, 5.ii.1908, C. French (MVMA); Victoria: 3 ex., Melbourne (ANIC); 1 ♀, Vic., Yarra Riv., Mellgrove, 4.i.1952, F. E. Wilson; 12 ♀, Vic., Jamieson, 20.iv.1943, F. E. Wilson; 1 ♂, 1 ♀, Victoria, Melbourne; 1 ♀, Victoria, Howitt Coll. (MVMA); 5 ♂, 2 ♀, Vic., Moorobool R., iv.1932 & iv.1951, F. E. Wilson (6 in MVMA, 1 in CV); New South Wales: 2 ♂, Surr. Sydney, N.S.W., Nikitin 1958 (ISNB); 1 ♀, N.S.W., Hornsby, 22.vii.1931, Harvard Exp. Darlington (MCZC); Queensland: Lectotype ♀; paralectotype ♀ (on same card as lectotype) (BMNH); 1 ♀, Caloundra, 21.iii.1963, C. Watts (CW); 2 ex. Nov. Holl.d, Cape York (MNHN); 1 ♀, Queensland, Biggenden, 22.i.1975. H. & A. Howden (CNCI); 2 ♀, Queensland (MVMA); 1 ♀, N. Qld, 11 km WSW of Petford, 3/4.iv.1988, R. I. Storey, at light; (QPI); 2 ♂, N. Qld, 7 km NE of Tolga, ii.1988, R. I. Storey & De Faveri, light trap (QPI, CV); 1 ♀, Queensland, Bundaberg, 31.iii.1963, C.Watts; 1 ♂, Queensland, Gin Gin, 2.iv.1963, C.Watts (CW); 1 ♀, Q., Brisbane, N. Pine R., 6.iii.1932, Harvard Exp. Darlington (MCZC); 1 ♂, Ashgrove, 2.v.1931, H. Hacker; 1 ♂, 1 ♀, N. Pine R., 10.iv.1933, H. Hacker; 2 ♂,

Brisbane, x.1892, C. Wild (QMBA); 1 ♂, N. Qld, Split Rock, 14 km S. of Laura, 23/26.vi.1975, C. Monteith (CV); 1 ♂, Brisbane (QMBA); 1 ♀, Q., Highvale, 8.ix.1965, B. Cantrell (UQIC); 1 ♂, Qld, Brisbane, 2.viii.1964, B. Cantrell (UQIC); 3 ex., Catherine Cr. nr Collins Weir, 20.ii.1990; 22 ex., nr Mt Mulligan, 31.i.1991, Larson & Halfpap (MUNC); Northern Territory: 1 ♂, Goose Lagoon, 16.10S, 136.1E, 11 km SW by S of Borroloola, 17.iv.1976, at light, J. E. Feehan (ANIC); 1 ♀, N.T., Horn Islet, Pellew Group, 25/31.i.1968, B. Cantrell (UQIC); Federal state unknown: 1 ex. (ANIC); 1 ex. without data; 1 ex. Nov. Holl. ex Museo Thorey (MNHN); 1 ♂, 1 ♀, Australia, coll. Wager (ISNB); 7 ♂, 5 ♀, Howitt coll.; 1 ♂, 1 ♀, unlabelled; 1 ♂, C. G. Oke (MVMA); 1 ♀, unlabelled (QMBA). — Indonesia: 1 ♀, Fort de Kock, Sumatra, 920 m., 1925, E. Jacobsen, *Haliplus pulchellus* det. A. Zimmermann [obviously mislabelled](ISNB). — Uruguay: 1 ♂, Montevideo, syntype *Haliplus nigrolineatus* Wehncke [obviously mislabelled](MNHN).

Haliplus signatipennis Régimbart
(Figs 97–111)

Haliplus signatipennis Régimbart, 1891: 979. Lectotype ♀ (here designated), '♀; N.Guinea mer., Rigo, luglio 1889, L.Loria; *signatipennis* Rég.; Museo Civ. Genova; Museum Paris, coll. Maurice Régimbart 1908' (MNHN) [examined].

Haliplus signatipennis; Régimbart 1899: 187; Zimmermann 1920: 316; 1924: 141; Watts 1988: 23.

Diagnosis

This species can be distinguished from other species in the region by the longitudinal dark mark on the pronotum.

Remarks

The specimen collected on Seram (Figs 106–111) is differing from the typical form in the secondary puncture-rows being almost as strong and dense as primary puncture-rows. As this only known specimen from Seram is a female it is not clear if it represents a separate species.

Description

Length 3.4–3.7 mm, width 1.9–2.1 mm. Body oval, parallel behind sligthly protruding shoulders (Fig. 97).

Head: Red-brown to brown, darkened near antennae. Weakly punctured. Antenna yellow-brown to yellow towards end, first five segments not longer than wide (Fig. 98). Palpi yellow-brown, last segment very short, about 1/4x penultimate segment. Distance between eyes 1.1–1.2x width of one eye.

Pronotum: Yellow-brown, large dark longitudinal mark in middle. Impressed basally, opposite elytral puncture-row 5–7 with strong, posteriorly well bordered impression. Moderately strongly and densely punctured, near hind corners a few widened punctures. Laterally not margined.

Elytra: Yellow-brown, very extensive dark maculation along base, suture and on intervals. Completely margined, no clear serration. Interval 2 slightly impressed. Primary puncture-rows moderately strong, about 32 punctures in row 1, row 4–7 stronger than adjacent rows. Secondary punctures along suture dense and moderately strong (Fig. 99), secondary puncture-rows on all intervals, on interval 9 behind central dark mark very dense row of secondary punctures. All punctures darkened and with hole in middle.

Underside: Red-brown to dark brown. Elytral epipleura yellow-brown, reaching to sternite 6. Legs yellow-brown (tarsus) to dark brown (femur). Prosternal process sinuate in anterior part and close to apex, anterior edge margined, laterally with clean grooves, in anterior third part moderately strongly punctured, in posterior 2/3 weakly punctured (Figs 101, 102). Metasternal process flat with lateral impressions, weakly punctured (Fig. 101). Metacoxal lobes not reaching sternite 5, moderately strongly, near suture weaker punctured. Sternite 5+6 with dense irregular puncture-rows, last sternite moderately strongly punctured, apical point with short ridge.

Setiferous striole on dorsal face of hind tibia about 1/5x length of tibia, longer tibial spur about 4/5x length of first tarsal segment (Fig. 100).

Male: Pro- and mesotarsomeres 1–3 widened and with sucker hairs on ventral side. Penis and parameres as in Figs 103–105.

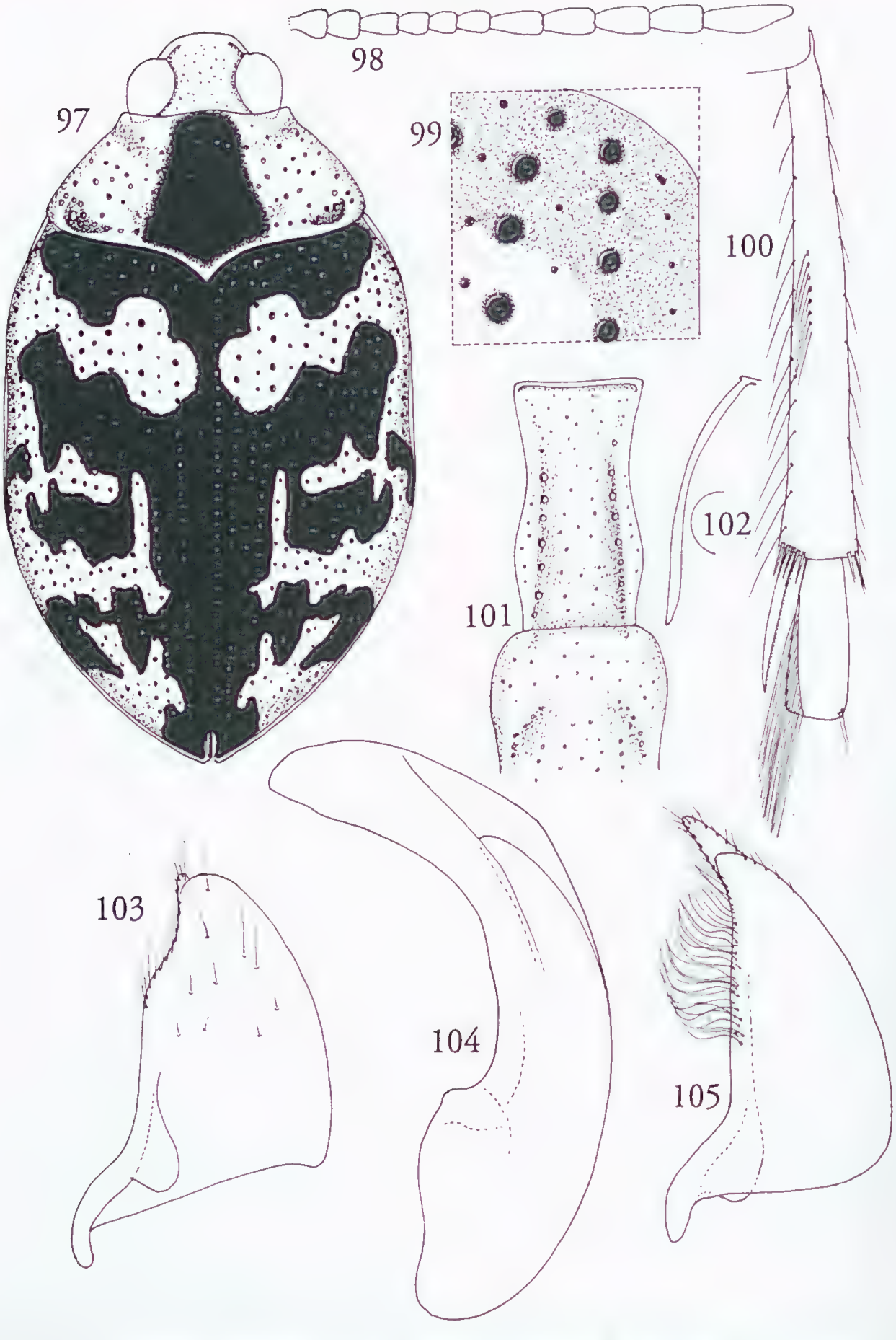
Biology

Specimens are collected in a stock pond, in a Sago swamp and in bomb craters.

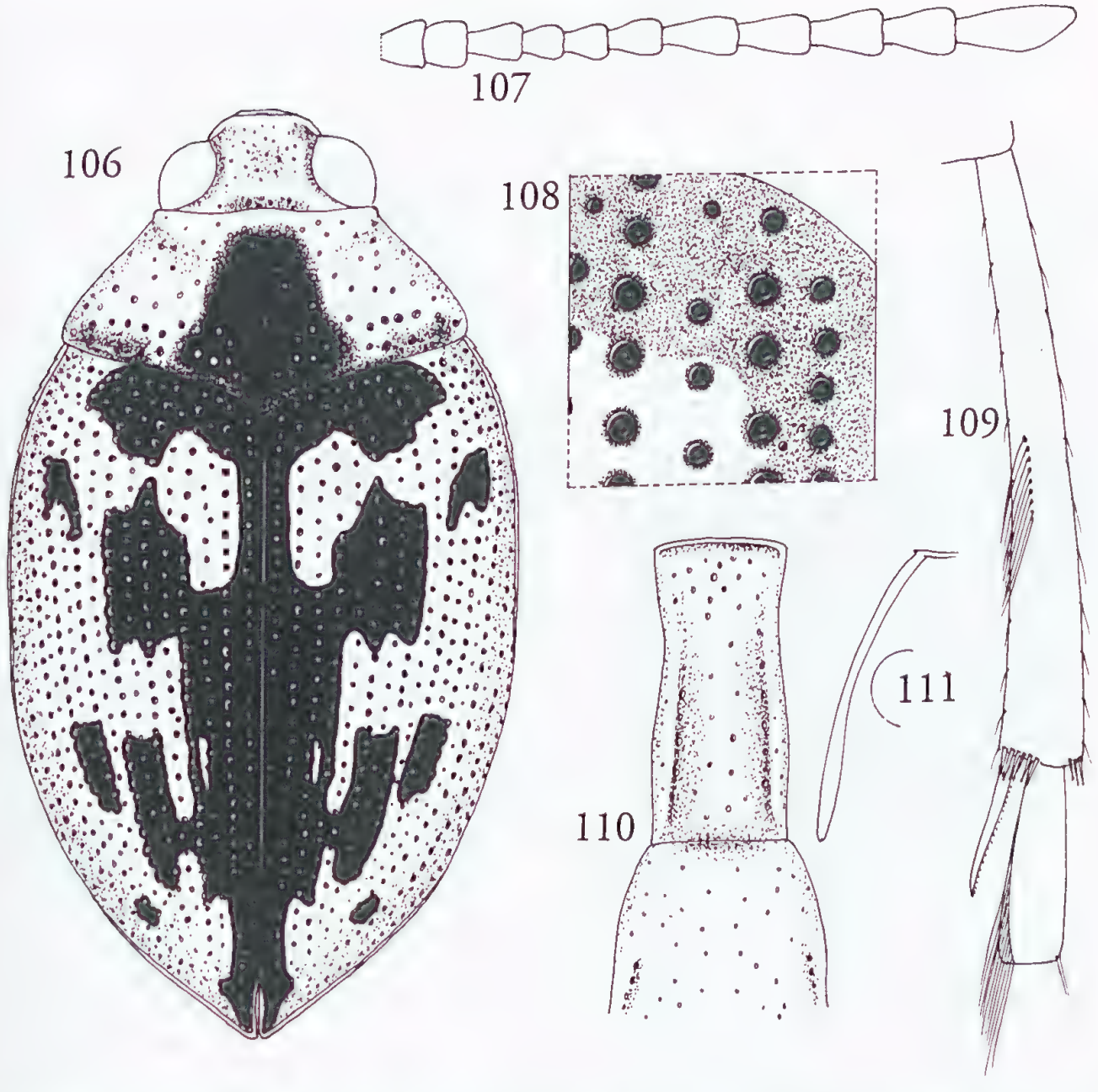
Distribution (Fig. 162)

Papua New Guinea. Indonesia: Seram.

Material examined: Papua New Guinea: Lectotype ♀ (MNHN); 3 ♂, 1 ♀, Madang, 5 km N. Alexishafen, sago swamp, 9.iii.1991; 1 ♂, Madang, 2 km W. Alexishafen, bomb craters, 1.iv.1991; 2 ♂, Ramu Vlly, Brahman Mission,



FIGURES 97–105. *Haliplus signatipennis*, **97–102**, Lectotype ♀; **103–105**, ♂ from Ramu Vlly: **97**, dorsal view; **98**, antenna; **99**, punctures near elytral base and suture; **100**, hind tibia; **101**, prosternal and metasternal process; **102**, prosternal process in lateral view; **103**, left paramere; **104**, penis; **105**, right paramere.



FIGURES 106–111. *Haliplus signatipennis*, ♀ from Seram: **106**, dorsal view; **107**, antenna; **108**, punctures near elytral base and suture; **109**, hind tibia; **110**, prosternal and metasternal process; **111**, prosternal process in lateral view.

stock pond, 17.iv.1991, Larson; 1 ♂, 1 ♀, Madang, Brahman Mission, 21 & 27.vi.1991, D. & M. Larson (MUNC). Indonesia: 1 ♀, Seram nr Wahai, leg. Jäch 1989 (NHMV).

Haliplus ferruginipes Régimbart
(Figs 112–117)

Haliplus ferruginipes Régimbart, 1891: 979. The type material (Papua New Guinea, Rigo) could not be found in Genoa (MCSN), where it should be, nor in Paris (MNHN).

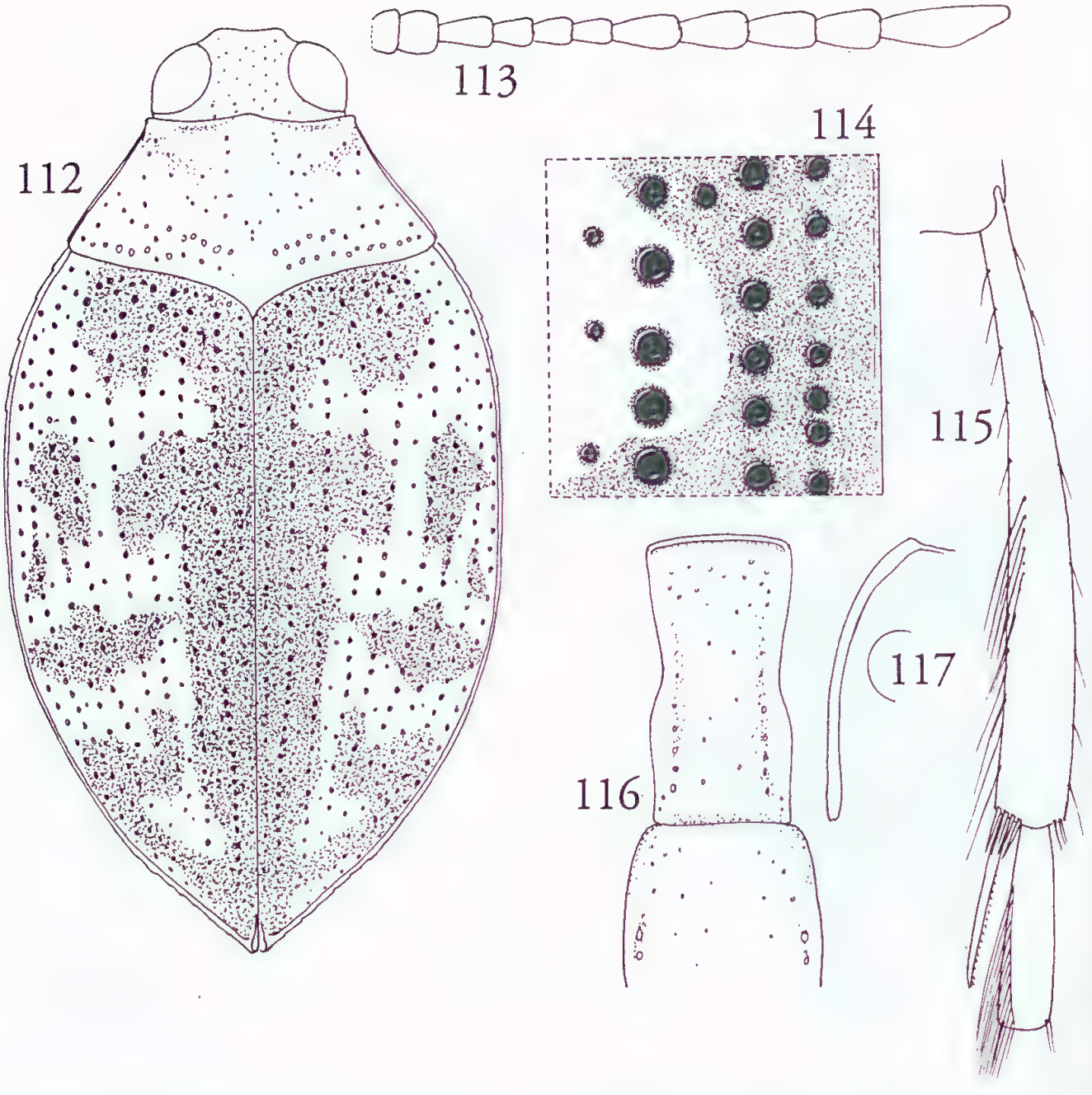
Haliplus nicholasi Watts, 1988: 23. Holotype ♀, 'Townsville, Qld Feb. 1972, T. Ingeldew, T–10793' (MVMA) [examined] **syn. n.**

Haliplus ferruginipes; Zimmermann 1920: 305; 1924: 142; Watts 1988: 23.

Remarks

A specimen from Merauke, New Guinea is considered to belong to this species as it matches the description of *H. ferruginipes*, although its length is 3.0 mm opposed to 3 4/5 mm as mentioned in the description. This specimen also resembles very much the types of *H. nicholasi*.

Although both species are only known from females making checking of male aedaegi



FIGURES 112–117. *Haliplus ferruginipes*, Holotype ♀ of *Haliplus nicholasi*: **112**, dorsal view; **113**, antenna; **114**, punctures near elytral base and suture; **115**, hind tibia; **116**, prosternal and metasternal process; **117**, prosternal process in lateral view.

impossible, I consider *H. ferruginipes* and *H. nicholasi* conspecific.

Diagnosis

This species can be distinguished from related species by the widely darkened elytral base in combination with puncture-row 5 not impressed basally.

Description

Length 3.3–3.6 mm, width 1.8–1.9 mm. Body oval, widest in middle (Fig. 112).

Head: Yellow-brown to yellow-red, anteriorly near antennae darkened, moderately strongly punctured. Antenna (Fig. 113) and palpi yellow-red to yellow-brown. Distance between eyes about 1.5x width of one eye.

Pronotum: Yellow-red, strongly punctured, on disc slightly weaker and sparser punctured, base slightly impressed. Lateral borders margined, margins narrowed anteriorly and hardly reaching front corner. Hind corners a little rounded.

Elytra: Yellow-red to yellow-brown, extensive dark confluent maculation along base to puncture-row 6, along suture to at least puncture-row 1 and on intervals. Primary puncture-rows moderately strong and dense, about 30 punctures in row 1, basal punctures of row 5 not in an impression.

Puncture-row 7+8 strong and a little impressed in middle, united to one row long before reaching base. Secondary punctures along suture nearly as strong as primary row 1 (Fig. 114), sparse but strong secondary punctures on interval 2, 3, 5, 7+9; interval 4, 6+8 unpunctured. All punctures darkened and with hole in middle. Completely margined, weakly and sparsely serrate in anterior part and weakly sinuate in apical part.

Underside: Yellow-red to yellow-brown, slightly darkened near prosternal en metasternal process, tarsi and tibia yellow-brown, femora brown. Elytral epipleura yellow with strong uncoloured punctures, reaching to sternite 6. Prosternal process sinuate in middle and just before apex, anteriorly finely margined, lateral puncture-rows in slight impression, in anterior half strongly punctured, in posterior half in middle sparsely punctured (Figs 116, 117). Prosternum anteriorly weakly margined. Metasternal process flat, moderately strongly but sparsely punctured, a few lateral punctures usually in slight impression (Fig. 116). Metacoxal lobes not reaching sternite 5, strongly punctured, near suture weakly punctured. Sternite 5+6 with strong and dense transverse puncture-row. Sternite 7 sparsely punctured, bulbous in lateral view, short clear ridge on apical point. Setiferous striole on dorsal face of hind tibia about 1/5x length of tibia, longer apical spur about 3/4x length of first tarsal segment (Fig. 115).

Male: unknown

Distribution (Fig. 156)

Australia: Northern Territory, northern part of Queensland. Papua New Guinea. Indonesia: West New Guinea.

Material examined: West New Guinea: 1 ♀, S. Neth. New Guinea, Merauke, sea level, 1.iv.1955, L. D. Brongersma (RMNH). Australia: 1 ♀holotype of *Haliplus nicholasi* Watts (MVMA); 1 paratype ♀ [not ♂ as label suggests], Homehill, Qld, 7.iv.1963, C.W., *Nicholasi* C. Watts 1984; 2 paratypes ♀, Cairns, Qld, 16.iv. 1963, C.W., *nicholasi* C. Watts 1984 (SAMA); 1 ♀, N.T., 6 km E. of Humpty Doo, 9.ii–4.iii.1987, R. I. Storey, *Haliplus nicholasi ms.nom* Det. C. Watts 1987 (QPI).

Haliplus alastairi Watts
(Figs 118–126)

Haliplus alastairi Watts, 1988: 24. Holotype ♂, 12°36'S 132°52'E Magela Creek, N.T. 1 km NNW of Mudginbarry HS. 25.v.1973, Matthews & Upton (ANIC).

Remarks

Part of the material Watts (1988) considered to belong to this species, belongs to a new species, *Haliplus timmsi*, described in this revision.

Diagnosis

This species can be distinguished from the related *H. timmsi* by the flat metasternal process of *H. alastairi* opposed to the metasternal process pitted on both sides of *H. timmsi*.

Description

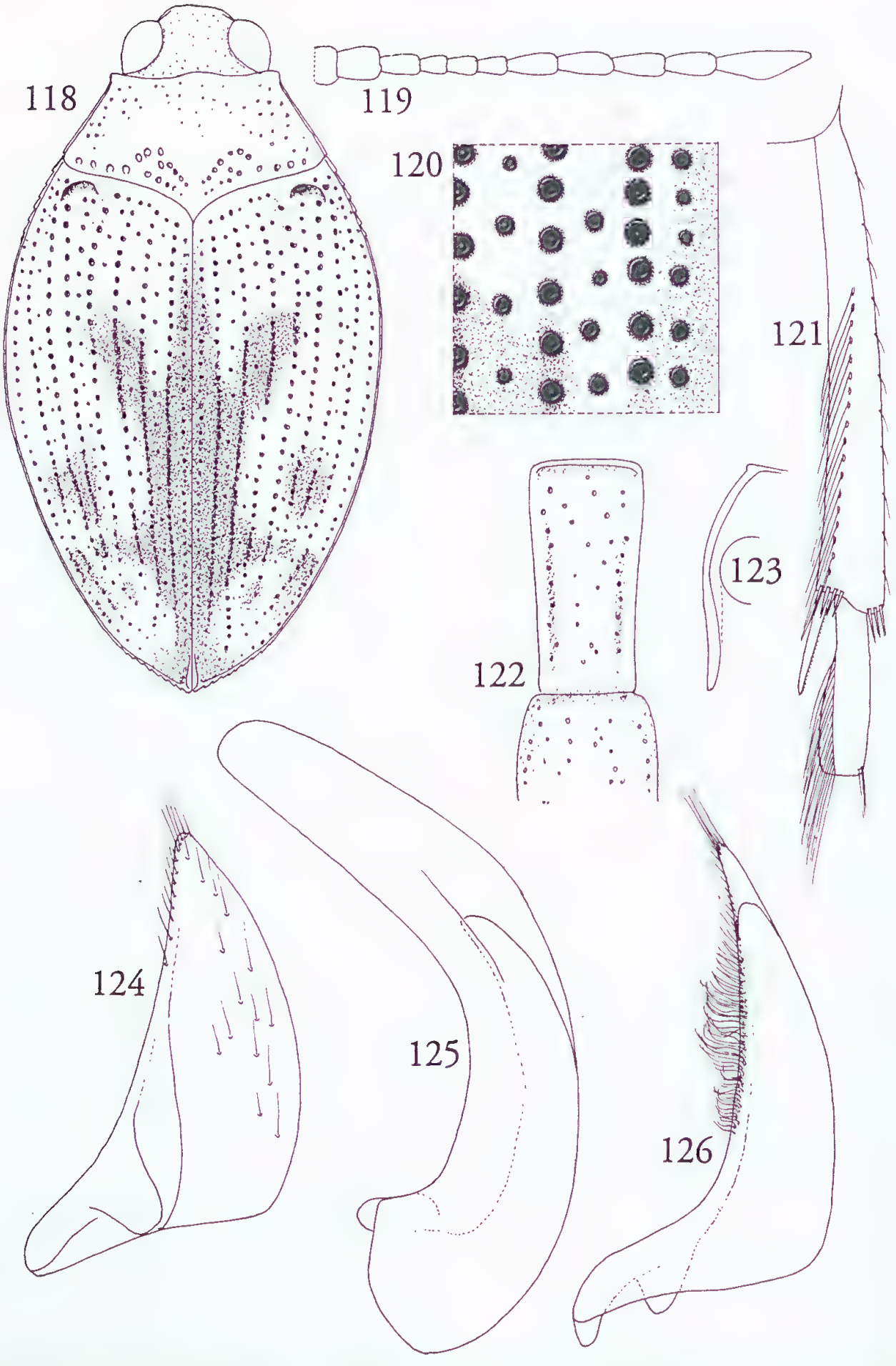
Length 3.0–3.6 mm, width 1.7–2.0 mm. Body oval, widest behind shoulders, clearly tapering in apical 1/3 part (Fig. 118).

Head: Yellow-brown, clypeus and frons weakly punctured, posterior part of vertex moderately strongly punctured. Antenna yellow to yellow-brown, fourth segment shorter than adjacent segments (Fig. 119). Palpi yellow, last segment about 1/2x length of penultimate segment. Distance between eyes 1.4–1.7x width of one eye.

Pronotum: Yellow-brown. Moderately strongly punctured, basal punctures opposite elytral puncture-row 4+5 slightly stronger and lying in transverse impression. Base hardly impressed. Lateral borders weakly margined, margin narrowed anteriorly and not reaching front corner. Anterior edge slightly protruding in middle.

Elytra: Yellow-brown with distinct dark markings. Darkened along most of suture and on parts of intervals, darkening on parts of puncture-rows. Primary puncture-rows moderately strong, first three rows weaker and denser than others, about 42 punctures in row 1. Row 5 abruptly bent outwards and ending in an inwards directed strong transverse impression, row 6 basally strong. Sutural row of secondary punctures about as strong as primary row 1 (Fig. 120). Secondary punctures near basal impression of primary row 5 strong. Sparse row of secondary punctures in interval 2, 3, 5+7. Interval 4, 6+8 with only a few punctures in anterior part. Completely margined, shoulders and apical margin serrate.

Underside: Yellow-brown to dark brown. Elytral epipleura yellow to yellow-brown, reaching to sternite 5. Legs yellow-brown to dark brown. Prosternum anteriorly margined, strongly, but not densely punctured. Prosternal process flat, nearly parallel, slightly narrowed just before apex, slightly diverging anteriorly, anterior edge margined, posteriorly weakly punctured, anteriorly stronger punctured (Figs 122, 123). Metasternal process flat with on each side some strong punctures, elsewhere weakly punctured (Fig. 122).



FIGURES 118–126. *Haliplus alastairi*, Holotype ♂: **118**, dorsal view; **119**, antenna; **120**, punctures near elytral base and suture; **121**, hind tibia; **122**, prosternal and metasternal process; **123**, prosternal process in lateral view; **124**, left paramere; **125**, penis; **126**, right paramere.

Metacoxal lobes not reaching sternite 5, moderately strongly to weakly punctured towards suture. Sternite 5+6 moderately, but especially laterally densely punctured. Sternite 7 fairly weakly punctured. Setiferous striole on dorsal face of hind tibia on posterior 2/3, longer tibial spur half as long as first tarsal segment (Fig. 121).

Male: Pro- and mesotarsomeres 1–3 widened and with sucker hairs on ventral side. Penis and parameres as in Figs 124–126.

Biology

Specimens were attracted to UV light placed in open forest.

Distribution (Fig. 163)

Australia: Northern part of Western Australia, Northern Territory, Queensland.

Material examined: Western Australia: 1 ♀, N. W.A., Kununurra, 22.xii.1991–6.i.1992, R. I. Storey (CV); 1 ♂, CALM-site 13/4, 12 km S. of Kalumburu Mission, 14.25S, 126.38E, 7–11.vi.1988, T. A. Weir, open forest (ANIC); Northern Territory: holotype ♂; 1 ♀ paratype Katherine, 9.ii.1968, at light, J. A. L. Watson (ANIC); 2 ♀, N.T., Grotty Pond, Newry Stn, 8.ii.1986, M. Tyler, M. Davies & G. Watson (SAMA); 1 ♂, Arnhem Land, Maningrida, 5 m., 16.iii.1961, J. L. Gressitt, light trap (BPBM); 2 ♂, 1 ♀, N.T., Horn Islet, Pellew Group, 25/31.i.1968, B. Cantrell (UQIC, CV); 1 ♀, N.T., 6 km E. of Humpty Doo, 9.ii–4.iii.1987, R. I. Storey (QPI); Queensland: 2 ♂ [on label indicated as ♀♀], Cairns, B. Allen (SAMA); 1 ♂, Q., Cairns,. Darlington (MCZC); 1 ♀, N. Qld, Iron range, Cape York Pen., 28.iv–4.v.1968, G. Monteith (UQIC); 1 ex., Cairns, C. J. W., PARATYPE *Haliplus alastairi* Watts 1984, T.11164 (QMBA); 1 ♂, N. Qld, Weipa, 15/16.iii.1989, G. Dickinson, at UV light (CV); 2 ♀, N. Qld, 10 km S. of Laura, 4.iii.1982, at light, J. Hasenpusch (QPI); 1 ♂, 1 ♀, Cardstone, 4–16.i.1968, K. Hyde, paratype; 1 ♀, Cook Town, N.Q., i.1971, G.B., paratype; 1 ♀, King River, 14.30S, 143.20E, 22.vi.1968, F. Parker, paratype (ANIC); 1 ♂, Qld, nr Mt Mulligan, 31.i.1991, Larson & Halfpap (MUNC); Federal state unknown: 1 ♂, Australia or Tasmania, Ploson [?], Mackay (MNHN).

Haliplus timmsi sp.n.

(Figs 127–135)

Type material: Holotype ♂, Lake Buchanan, Qld, 21.30S/45.50E, B. Timms, 25.ix.1953, PARATYPE *Haliplus alastairi* C. Watts 1984 (SAMA). Paratypes: 4 ♀, N. T., Grotty Pond, Newry Stn, 8.ii.1986, M. Tyler, M. Davies & G. Watson, *Haliplus alastairi* sp.nov. det. C. Watts '86 (SAMA); 1 ♂, 1 ♀, N. Qld, Pinnarendi Stn 60 km W. of Mt Garnet, 7.ii.1989, D. Heiner (QPI, CV); 1 ♂, 2 ♀, N. Qld, 10 km S. of Laura, 4.iii.1992, at light, J. Hasenpusch (2 in QPI, 1 in CV); 3 ♂, 9 ♀, N. Qld 7km NE of Tolga, ii.1988, Storey & De Faveri, light trap (12 in QPI, 1 in CV); 1 ♀, N. Qld, 7 km NE of Tolga, iii.1987, Storey & De Faveri, light trap (QPI); 1 ♂, 1 ♀, 11 km WSW of Petford, 3/4.iv.1988, R. I.Storey, at light (QPI, CV); 1 ♂, Katharine, N.T., at light, 9.ii.1968, J. A. L. Watson, *Haliplus* sp.nov. det. T. A. Weir, paratype *Haliplus alastairi* C. Watts 1984 (ANIC); 1 ♂, 2 ♀, Edge Hill, N.Q., ii.1954, G.B. (2 in ANIC, 1 in CV).

Remarks

Some paratypes of *Haliplus alastairi* Watts belong to this new species.

Diagnosis

This species can be distinguished from the related *H. alastairi* by the metasternal process being impressed on both sides.

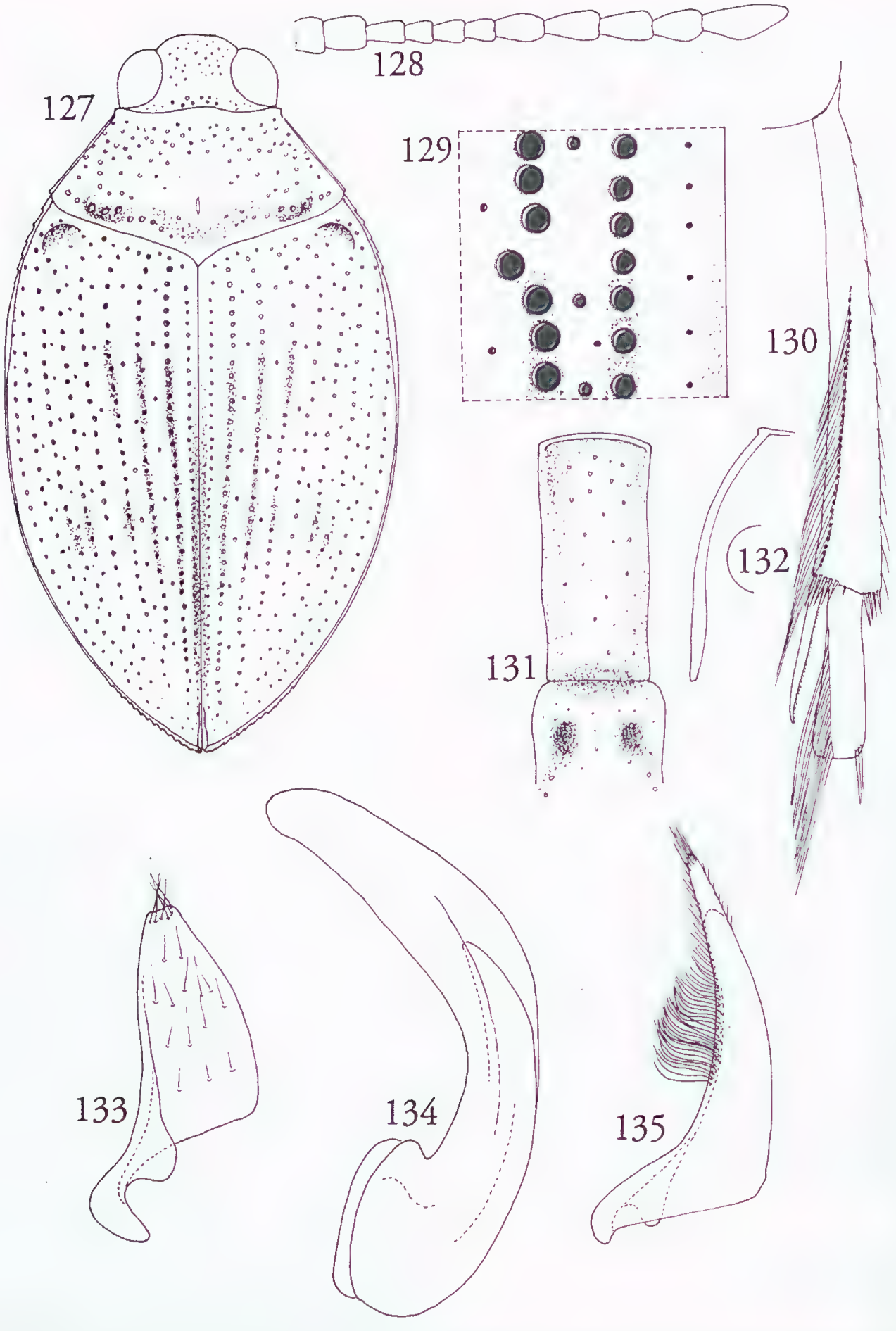
Description

Length 3.0–3.6 mm, width 1.7–2.0 mm. Body oval, widest behind shoulders, clearly tapering in apical 1/3 part (Fig. 127).

Head: Yellow-brown, clypeus and frons weakly punctured, posterior part of vertex moderately strongly punctured. Antenna yellow to yellow-brown, fourth segment shorter than adjacent segments (Fig. 128). Palpi yellow, last segment about 1/2x length of penultimate segment. Distance between eyes 1.5–2.0x width of one eye.

Pronotum: Yellow-brown. Moderately strongly punctured, basal punctures opposite elytral puncture-row 4+5 slightly stronger, base with clear impression. Lateral borders weakly margined, margin narrowed anteriorly and not reaching front corner. Anterior edge slightly protruding in middle.

Elytra: Yellow-brown. Darkened along most of suture, darkening on parts of puncture-rows, or rarely with marks connecting puncture-rows. Primary puncture-rows moderately strong, first three rows weaker and denser than others, about 42 punctures in row 1. Row 5 abruptly bent outwards and ending in an inwards directed strong transverse impression. Row 6 basally weak. Sutural row of secondary punctures weak. Sparse row of secondary punctures in interval 2, 3, 5+7.



FIGURES 127–135. *Haliplus timmsi*, Holotype ♂: **127**, dorsal view; **128**, antenna; **129**, punctures near elytral base and suture; **130**, hind tibia; **131**, prosternal and metasternal process; **132**, prosternal process in lateral view; **133**, left paramere; **134**, penis; **135**, right paramere.

Interval 4, 6+8 with only a few punctures in anterior part. Secondary punctures near basal impression of row 5 weak. Completely margined, shoulders and apical margin serrate.

Underside: Yellow-brown to dark brown. Elytral epipleura yellow to yellow-brown, reaching to sternite 5. Legs yellow-brown to dark brown. Prosternum anteriorly margined, strongly, but not densely punctured. Prosternal process flat, nearly parallel, slightly narrowed just before apex, slightly diverging anteriorly, anterior edge margined, posteriorly weakly punctured, anteriorly stronger punctured (Figs 131, 132). Metasternal process flat with on each side small very deep impression, weakly punctured (Fig. 131). Metacoxal lobes not reaching sternite 5, moderately strongly to weakly punctured towards suture. Sternite 5+6 moderately, but especially laterally densely punctured. Sternite 7 fairly weakly punctured. Setiferous striole on dorsal face of hind tibia on posterior 2/3, longer tibial spur almost as long as first tarsal segment (Fig. 130).

Male: Pro- and mesotarsomeres 1–3 widened and with sucker hairs on ventral side. Penis and parameres as in Figs 133–135.

Biology

Specimens were attracted to light.

Distribution (Fig. 164)

Australia: Queensland, Northern Territory.

Haliplus stepheni Watts
(Figs 136–146)

Haliplus stepheni Watts, 1988: 25. Holotype ♀, Australia, N.T., Humpty Doo, 6 km E., 9.ii–4.iii.1987, R. I. Storey (SAMA)[examined].

Diagnosis

This species can be distinguished from related species by the combination of a darkened elytral base and elytral puncture-row 5 with a strong transverse impression on base.

Description

Length 2.8–3.0 mm, width 1.5–1.6 mm. Body long oval, widest in middle (Fig. 136).

Head: Yellow, weakly punctured. Antenna (Fig. 137) and palpi yellow. Last segment of maxillair palpus about half length of penultimate segment (Fig. 139). Last segment of labial palpus about 2/3x length of penultimate segment (Fig. 140). Distance between eyes 1.5–1.6x width of one eye.

Pronotum: Yellow to yellow-red, usually dark blotch on anterior central part. Moderately strongly punctured, basally opposite elytral puncture-row 4 transverse impression, surrounded by strong punctures, lateral borders slightly concave, margined except near front corner, margin stronger posteriorly.

Elytra: Yellow to yellow-red, distinct dark maculation consisting of: black suture reaching secondary row 1 or in apical part reaching to primary row 1, black band along base to puncture-row 5, marks confluent with suture on disc and in posterior part, large marks in anterior, in central and in posterior part. Primary punctures strong and with clear central hole, about 28 punctures in row 1, basal punctures of row 5 in strong impression. Punctures in row 1+2 less strong than in row 3–6 or 7. Secondary punctures usually strong, generally restricted to odd intervals. All punctures darkened. Lateral sides margined, slightly constricted in posterior part, serrate in anterior part (about 7 teeth) and in posterior part (about 7 teeth).

Underside: Yellow to yellow-brown, legs yellow to brown towards coxae. Elytral epipleura yellow, reaching sternite 6, in anterior part with strong darkened punctures. Prosternum margined anteriorly, strongly punctured. Prosternal process about parallel-sided, sligthly narrowed near coxae, grooved along both sides, strongly and densely punctured, clearly margined anteriorly (Fig. 142, 143). Metasternal process flat or slightly elevated in middle, grooved along both sides, weakly punctured (Fig. 142). Metacoxal lobes moderately strongly, near suture weaker punctured, not reaching posterior margin of sternite 4. Sternite 5+6 posteriorly with complete puncture-row, sternite 7 with a few punctures in apical part. Setiferous striole on dorsal face of hind tibia about 1/3x tibia-length, longer tibial spur 2/3x length of first tarsal segment (Fig. 141).

Male: Pro- and mesotarsomeres 1–3 widened and with sucker hairs on ventral side. Penis and parameres as in Figs 144–146.

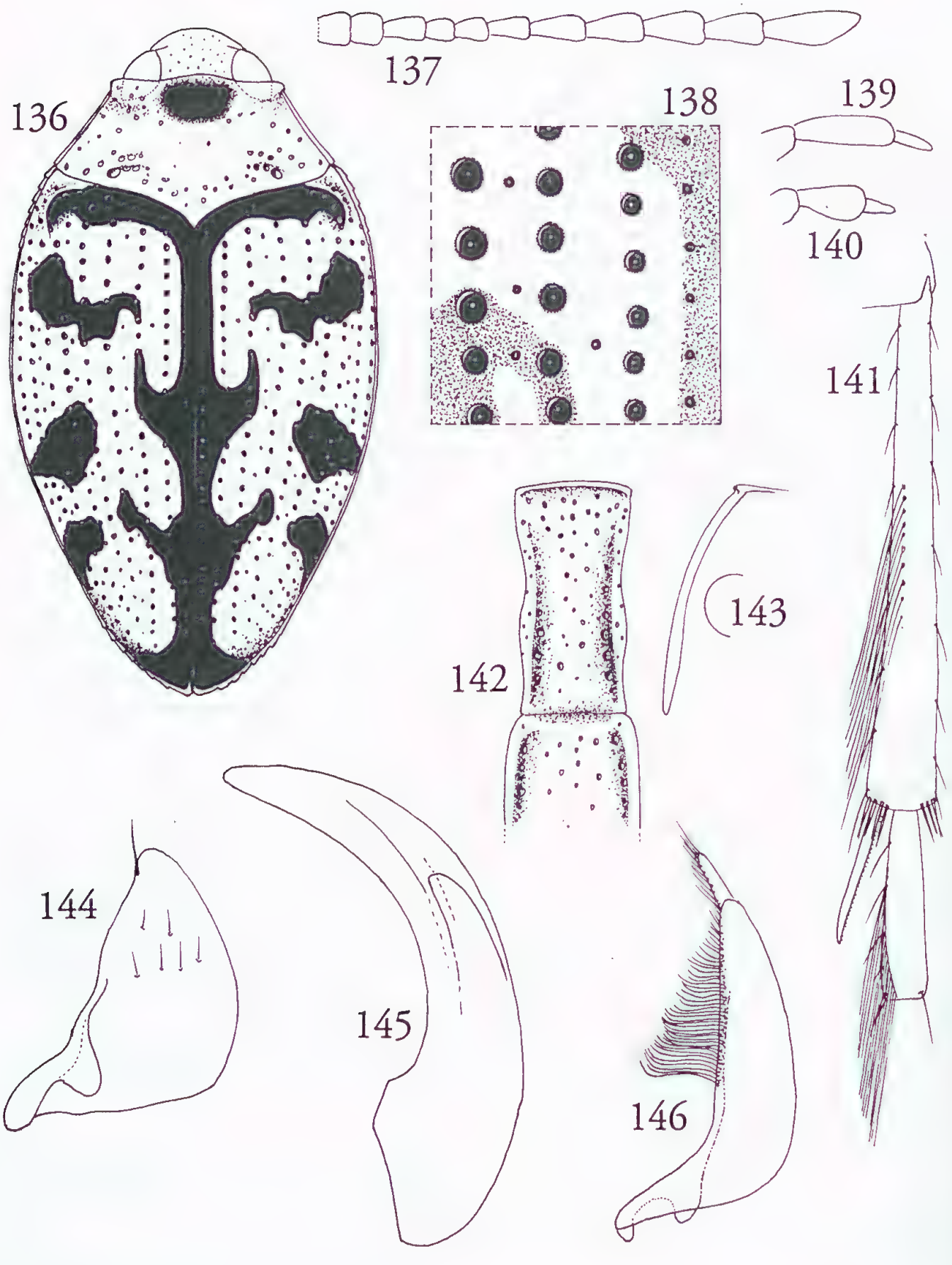
Biology

Specimens were collected in a creek and were attracted to light.

Distribution (Fig. 162)

Australia: Western Australia, Northern Territory, Queensland.

Material examined: Western Australia: 1 ♂, N. W.A., Kununurra, 22.xii.1991–6.i.1992, R. I.



FIGURES 136–146. *Haliplus stepheni*, **136-143**, Holotype ♀; **144–146**, Paratype ♂: **136**, dorsal view; **137**, antenna; **138**, punctures near elytral base and suture; **139**, maxillair palpus; **140**, labial palpus; **141**, hind tibia; **142**, prosternal and metasternal process; **143**, prosternal process in lateral view; **144**, left paramere; **145**, penis; **146**, right paramere.

Storey (CV); Northern Territory: Holotype ♀ (SAMA); 8 paratypes with same data as holotype (1 ♂ in CW; 4 ♂, 3 ♀ in QPI); Queensland: 1 ♀, N. Qld, 11 km WSW of Petford, 3/4.iv.1988, R. I. Storey, at light (QPI); 2 ex. Gunshot Ck, 13 km WNW of Heathlands, 11.43S, 142.26E, 18.iii.1992, at light, D. C. F. Rentz (ANIC, CV); 1 ♀, Qld nr Mt Mulligan, 31.i.1991, Larson & Halfpap (MUNC).

Haliplus sindus Watts
(Figs 147–152)

Haliplus sindus Watts, 1988: 22. Holotype ♀, Qld Bentinck Is. 'Ninyilki' 6 June 1963. P. Aitken, N. B. Tindale. (SAMA)[examined].

Diagnosis

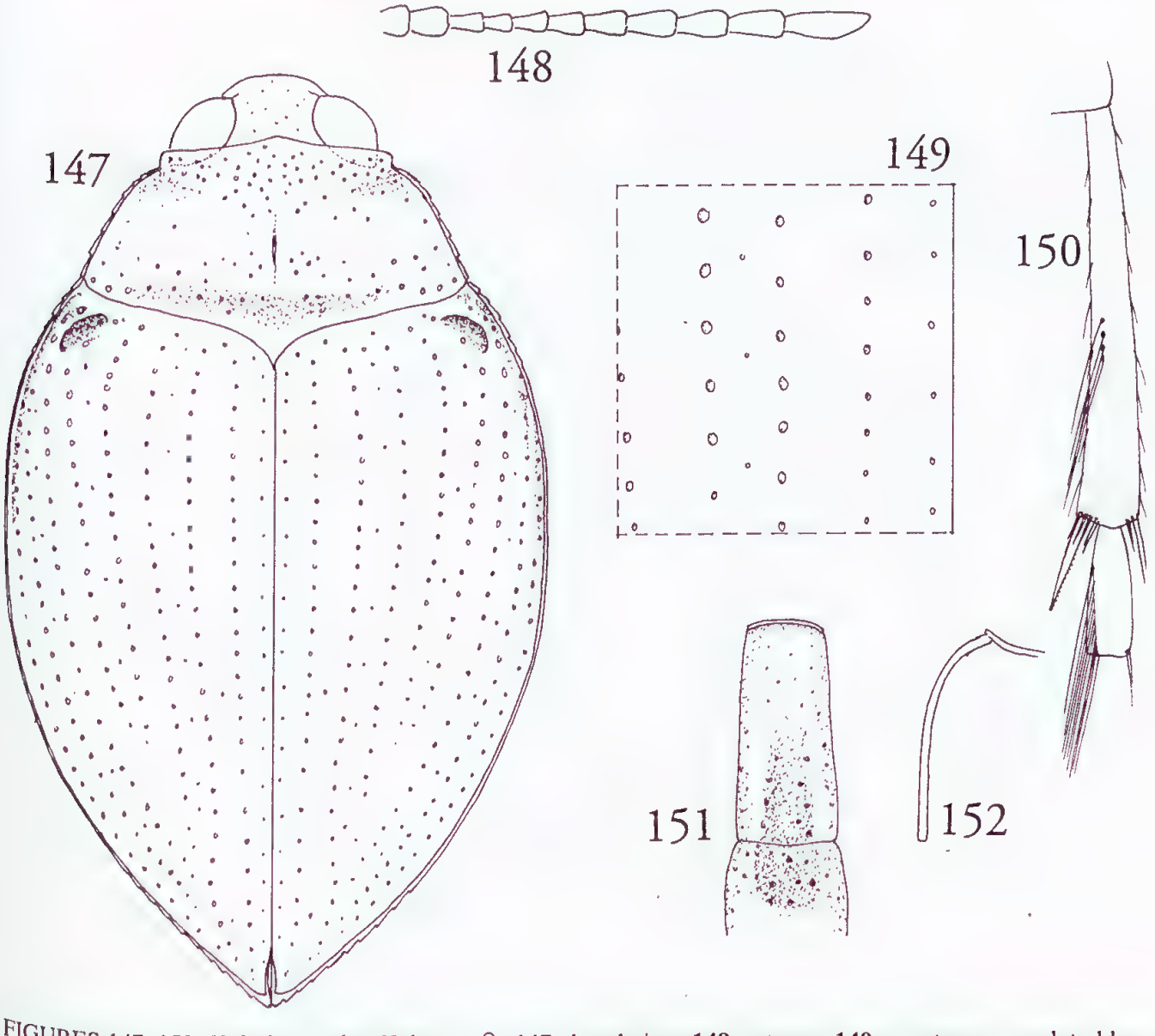
This species is easy to distinguish from others in the region by its small size and the serrate lateral margins of pronotum.

Description

Length 1.7–2.2 mm, width 1.1–1.3 mm. Body oval, strongly tapering posteriorly, widest in front of middle (Fig.147).

Head: Yellow to yellow-red, weakly and sparsely punctured. Antenna (Fig. 148) and palpi yellow. Last segment of maxillair palpi 1/3x length of penultimate segment. Last segment of labial palpi almost as long as penultimate segment. Distance between eyes 1.4–1.5x width of one eye.

Pronotum: Yellow to yellow-red, weakly punctured, in anterior central part more strongly and densely punctured, base impressed. Lateral borders slightly convex, anteriorly bent inwards, lateral margins clearly serrate, not reaching anterior corner (Fig. 147).



FIGURES 147–152. *Haliplus sindus*, Holotype ♀: **147**, dorsal view; **148**, antenna; **149**, punctures near elytral base and suture; **150**, hind tibia; **151**, prosternal and metasternal process; **152**, prosternal process in lateral view.

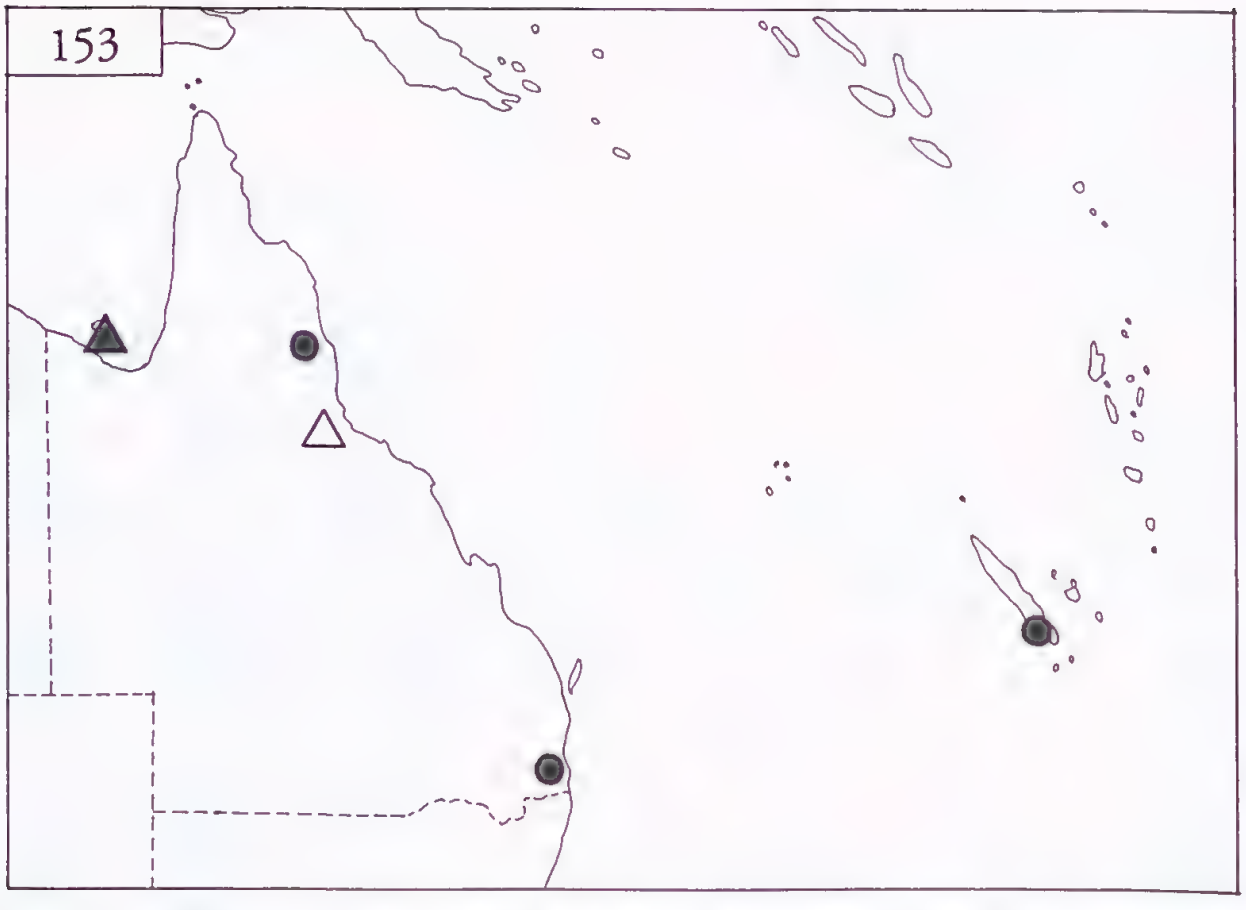


FIGURE 153. Distribution of *Haliplus oberthuri* (dots) and *Haliplus sindus* (triangle, black: examined; open: unexamined paratype).

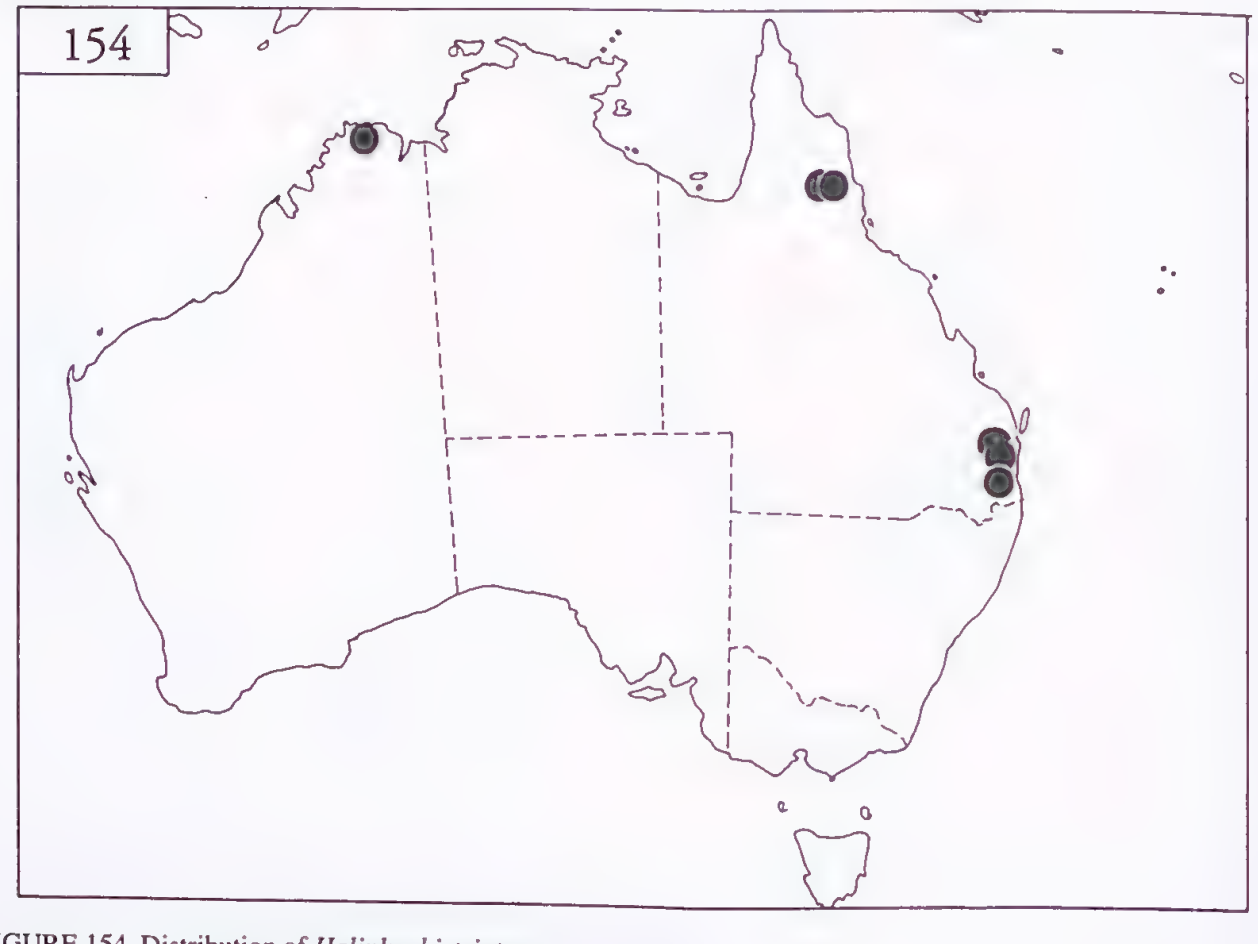


FIGURE 154. Distribution of *Haliplus bistriatus*.

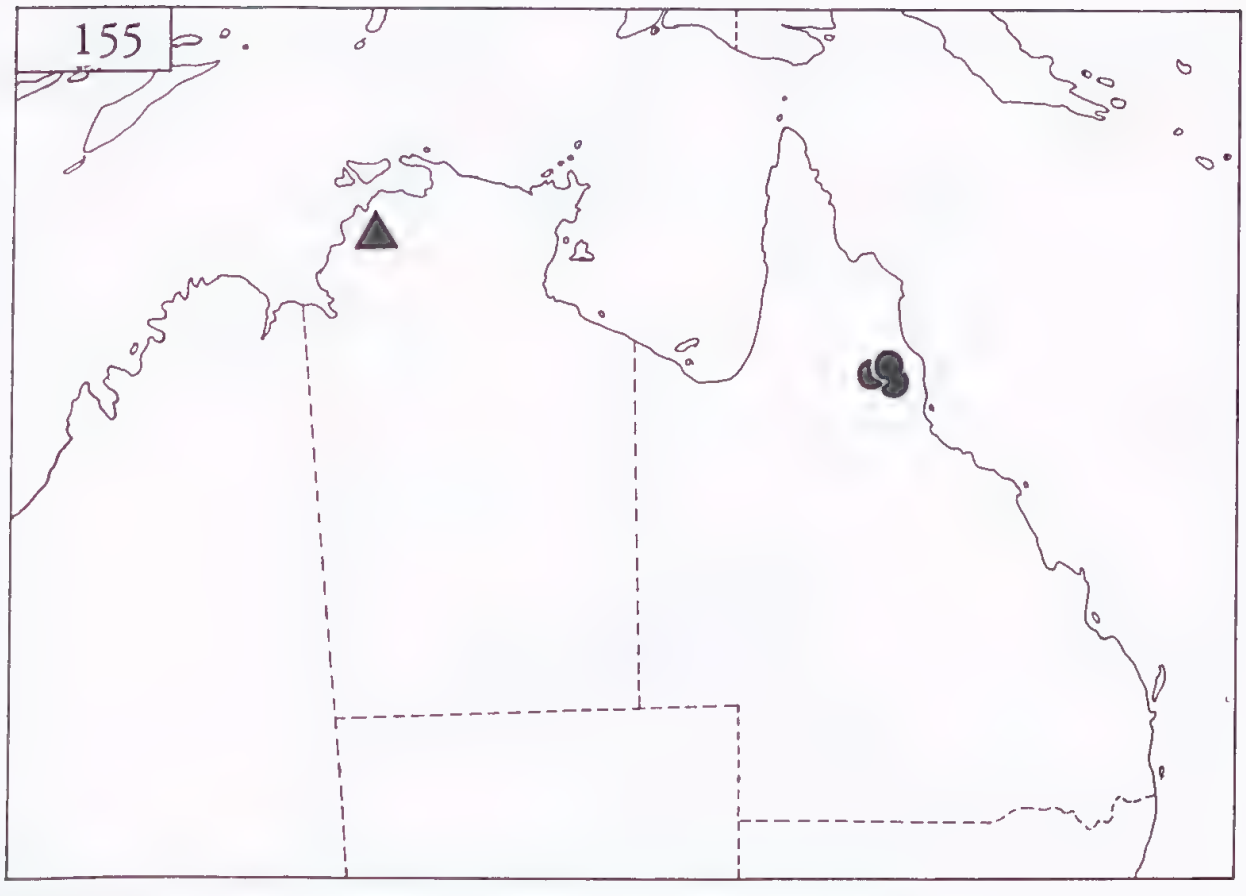


FIGURE 155. Distribution of *Haliplus hydei* (dots) and *Haliplus storeyi* (triangle).

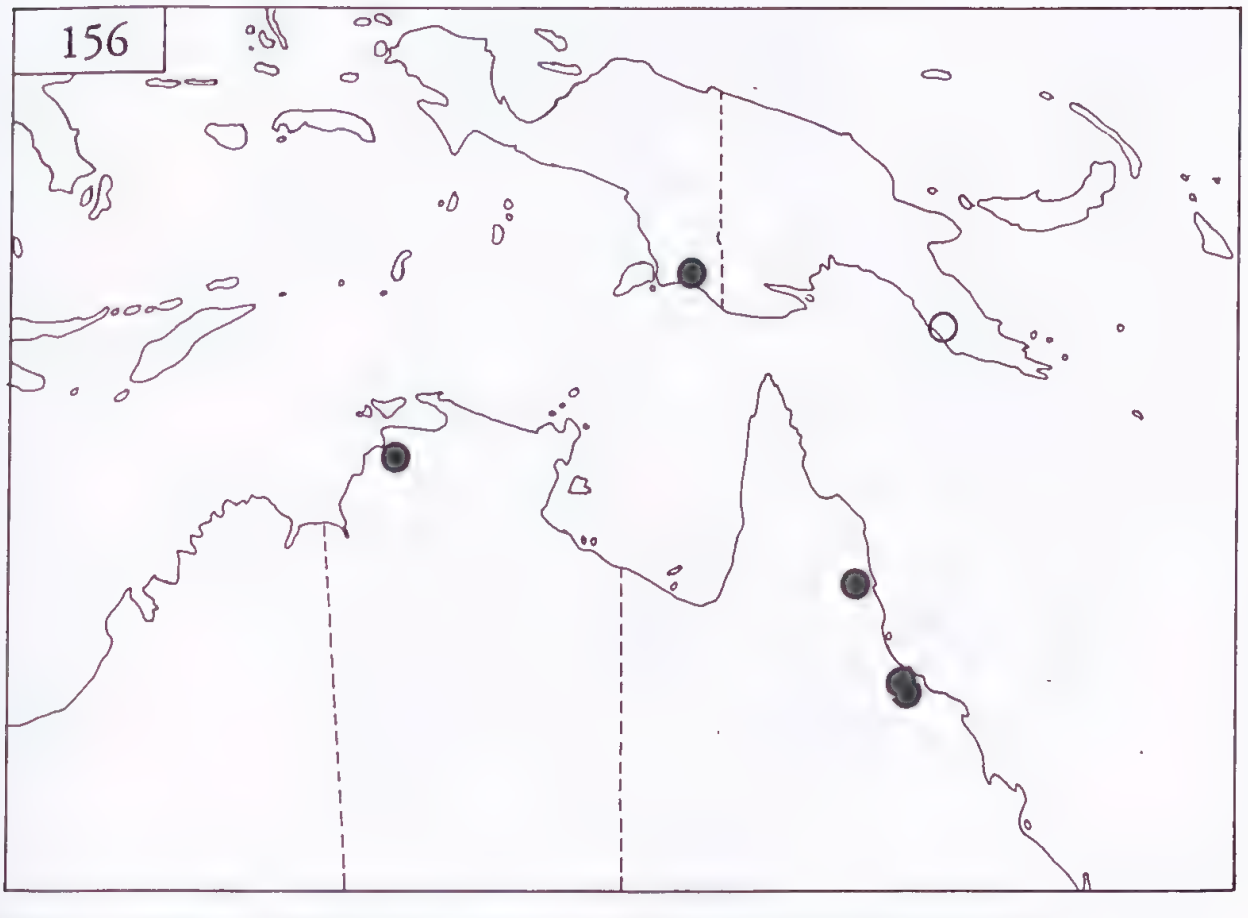


FIGURE 156. Distribution of *Haliplus ferruginipes*. (Dot: examined, circle: not examined type.)

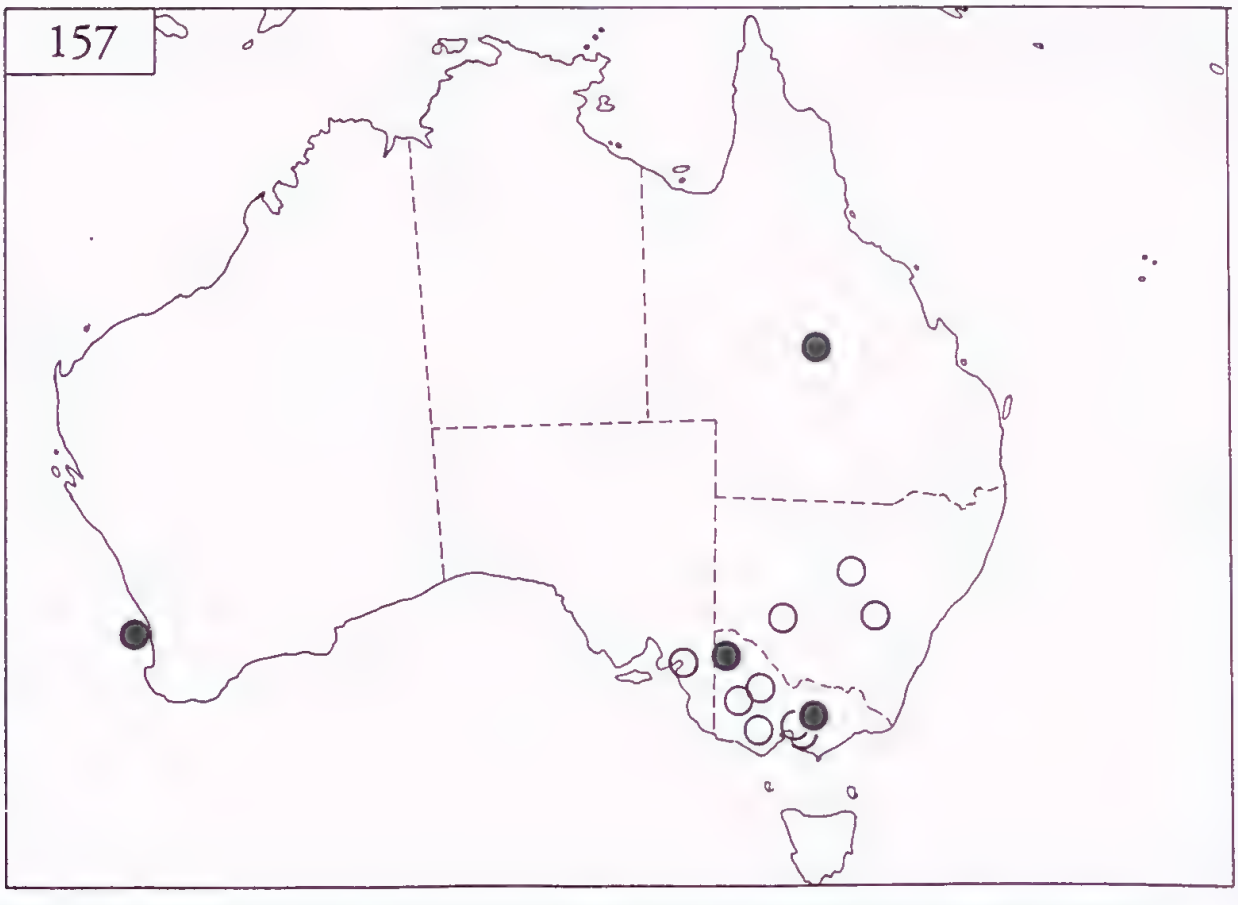


FIGURE 157. Distribution of *Haliplus fuscatus* (dots: males; circles: females of *H. fuscatus* or *H. gibbus*).

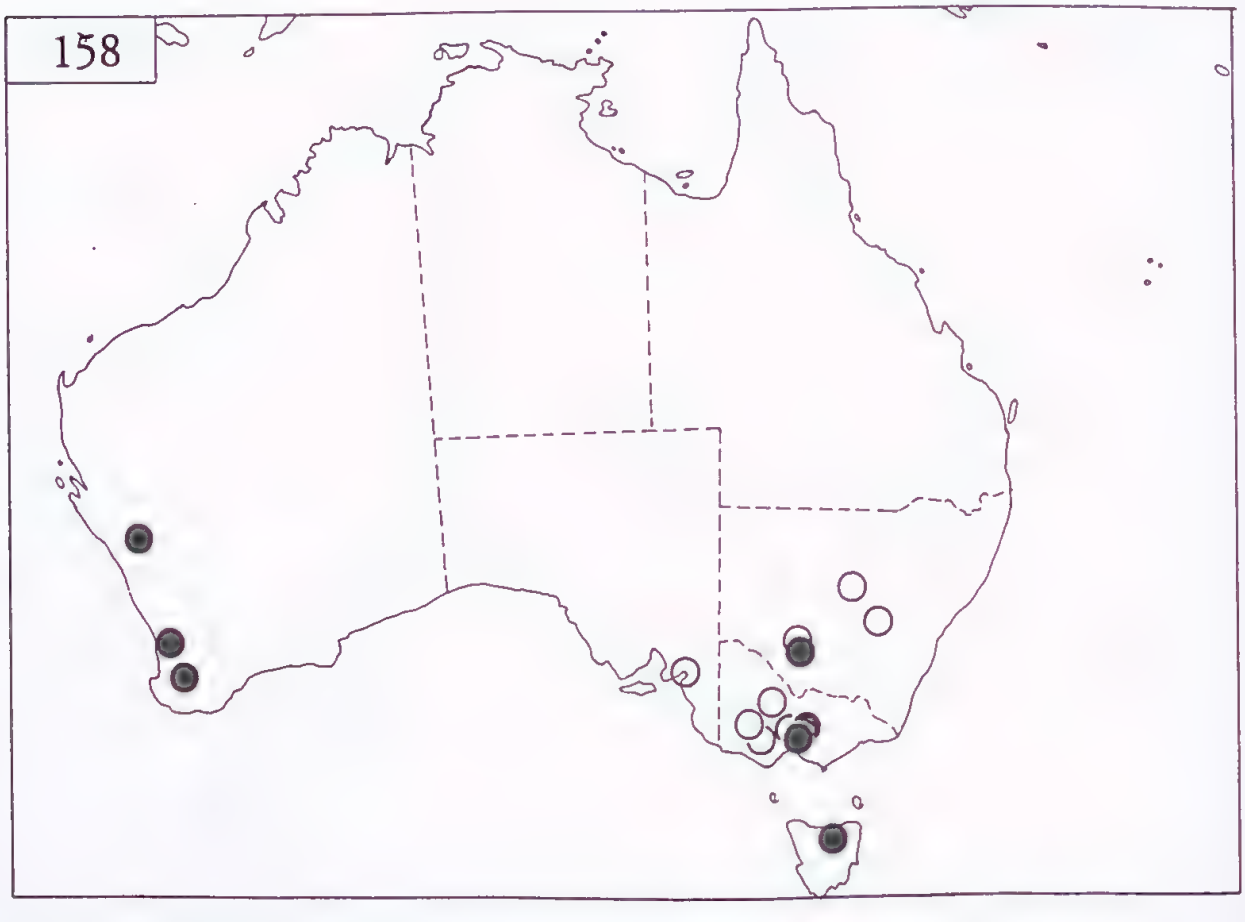


FIGURE 158. Distribution of *Haliplus gibbus* (dots: males; circles: females of *H. gibbus* or *H. fuscatus*).

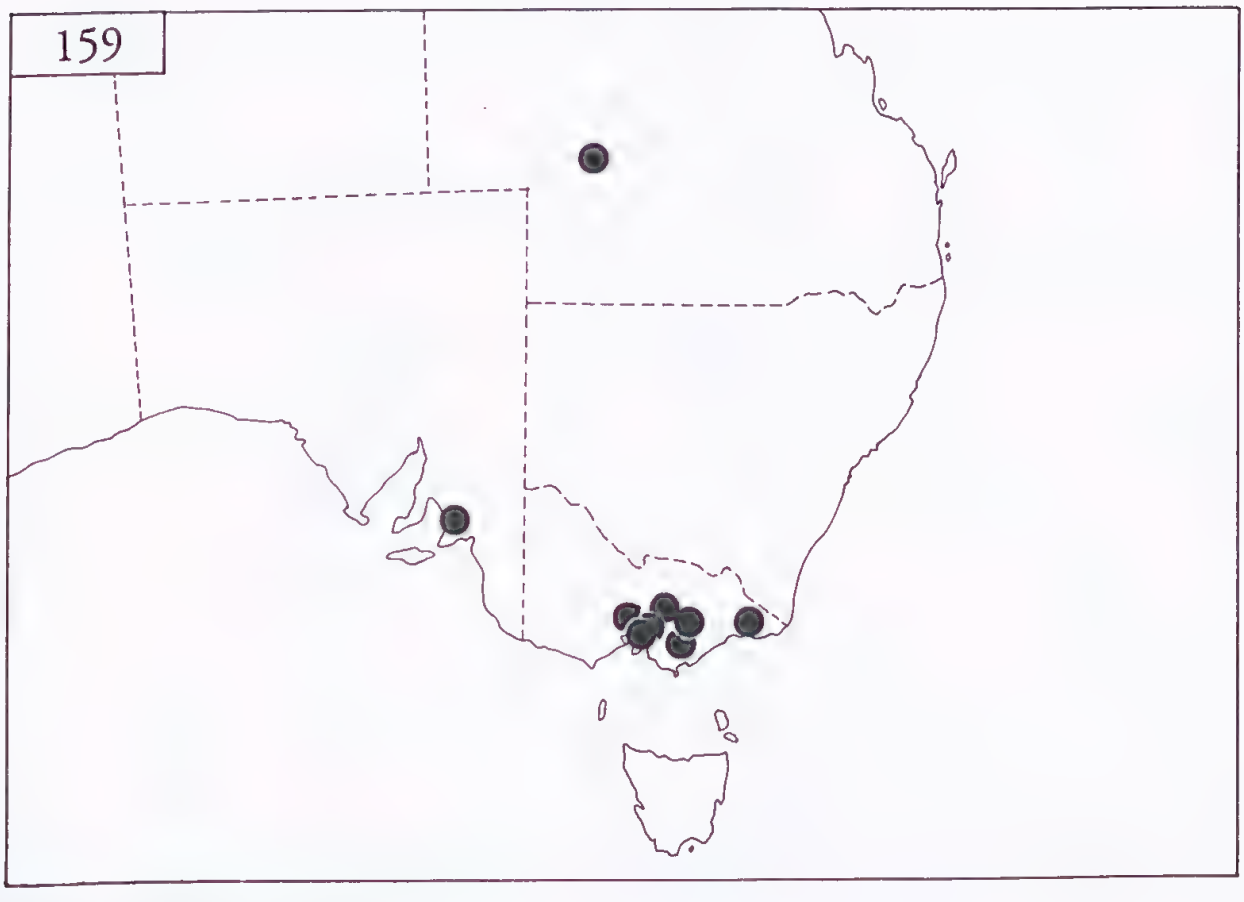


FIGURE 159. Distribution of *Haliplus australis*.

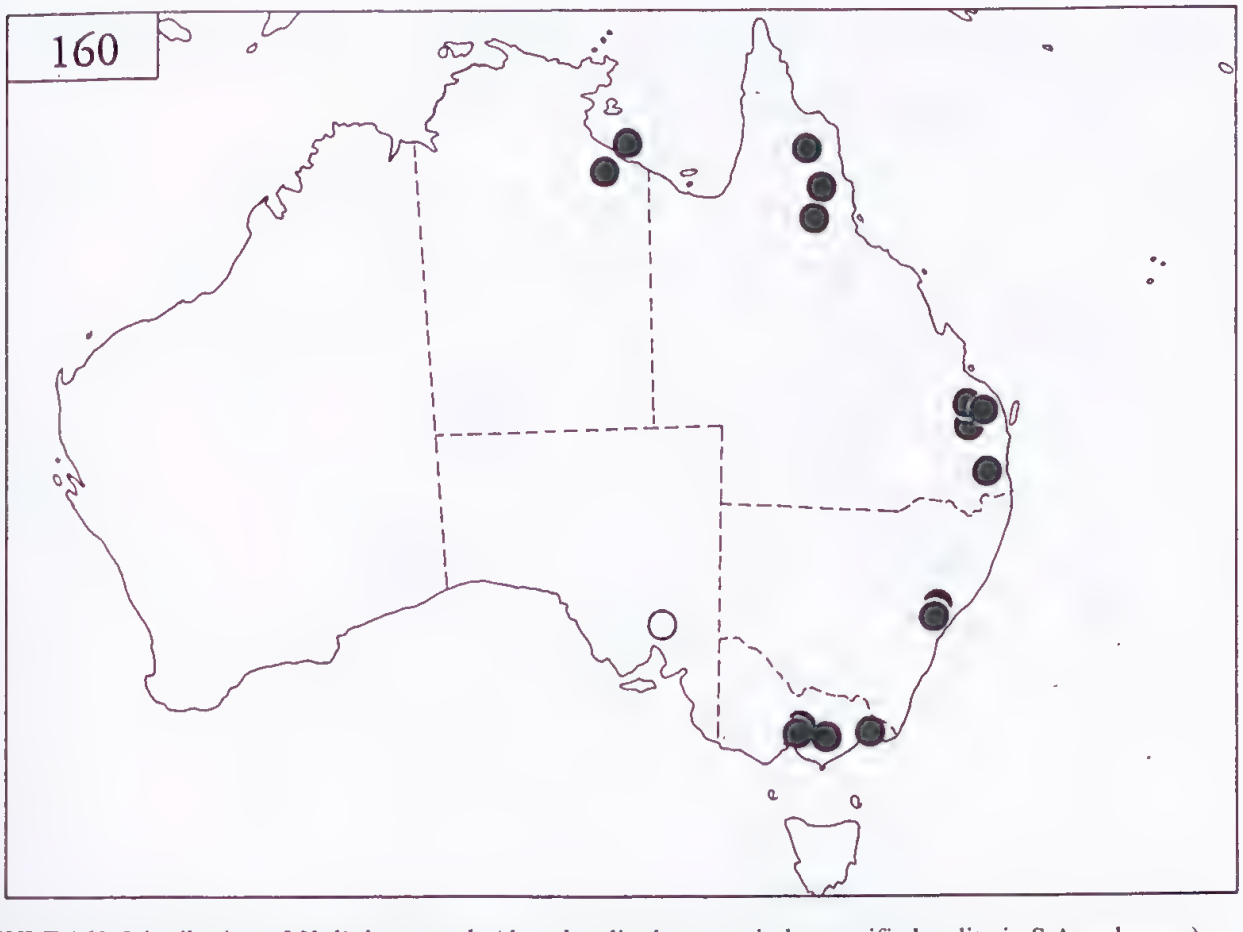


FIGURE 160. Distribution of *Haliplus testudo* (dots: locality known; circle: specific locality in S.A. unknown).

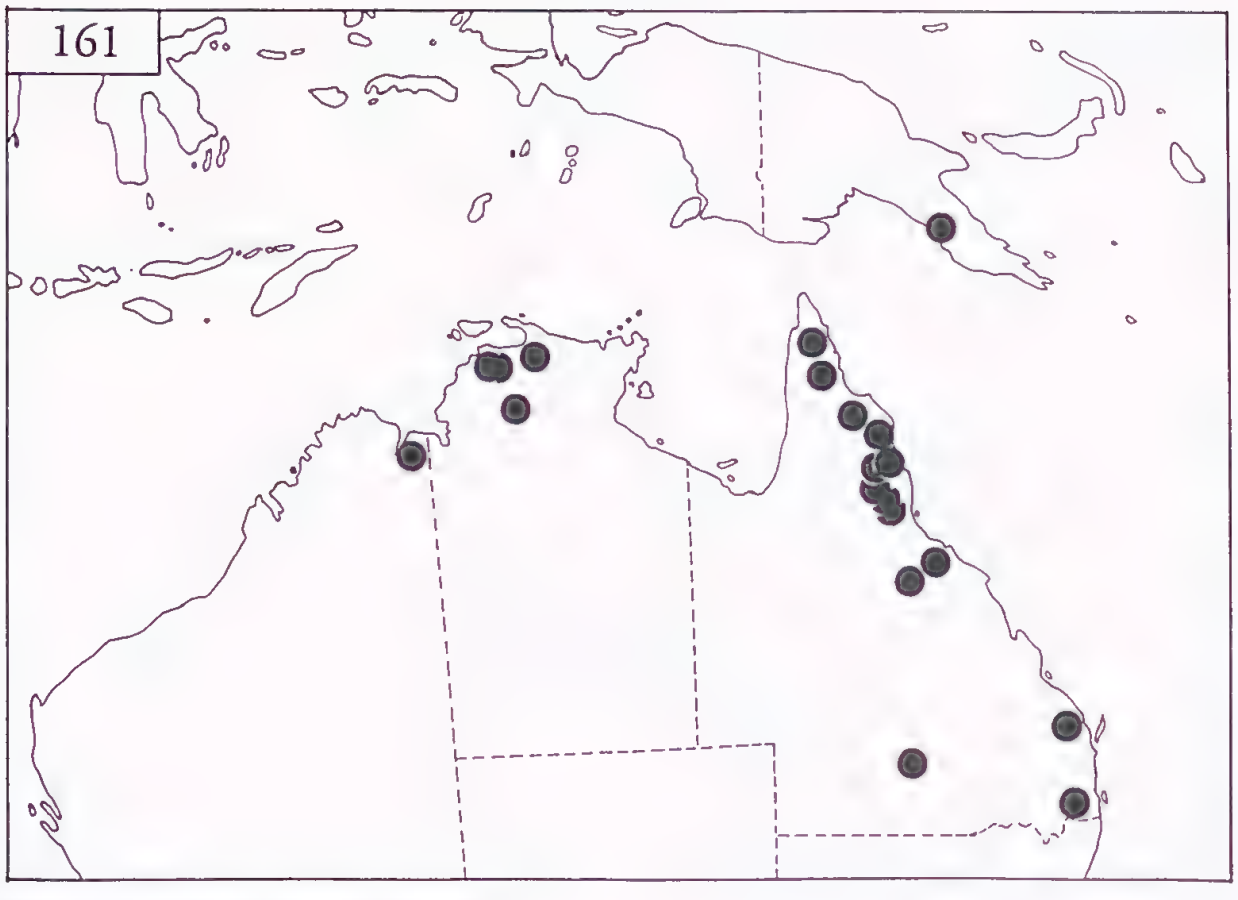


FIGURE 161. Distribution of *Haliplus wattsi*.

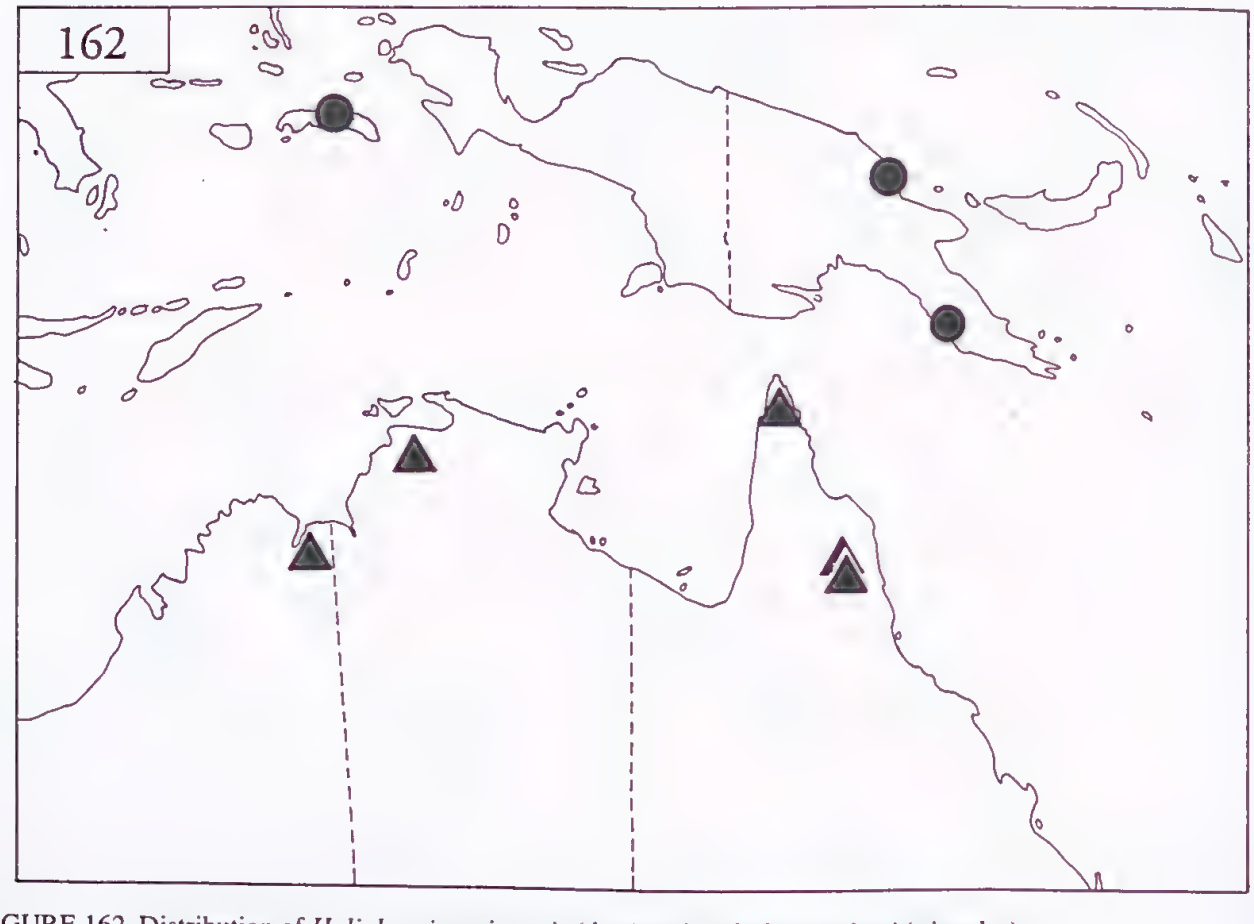


FIGURE 162. Distribution of *Haliplus signatipennis* (dots) and *Haliplus stepheni* (triangles).

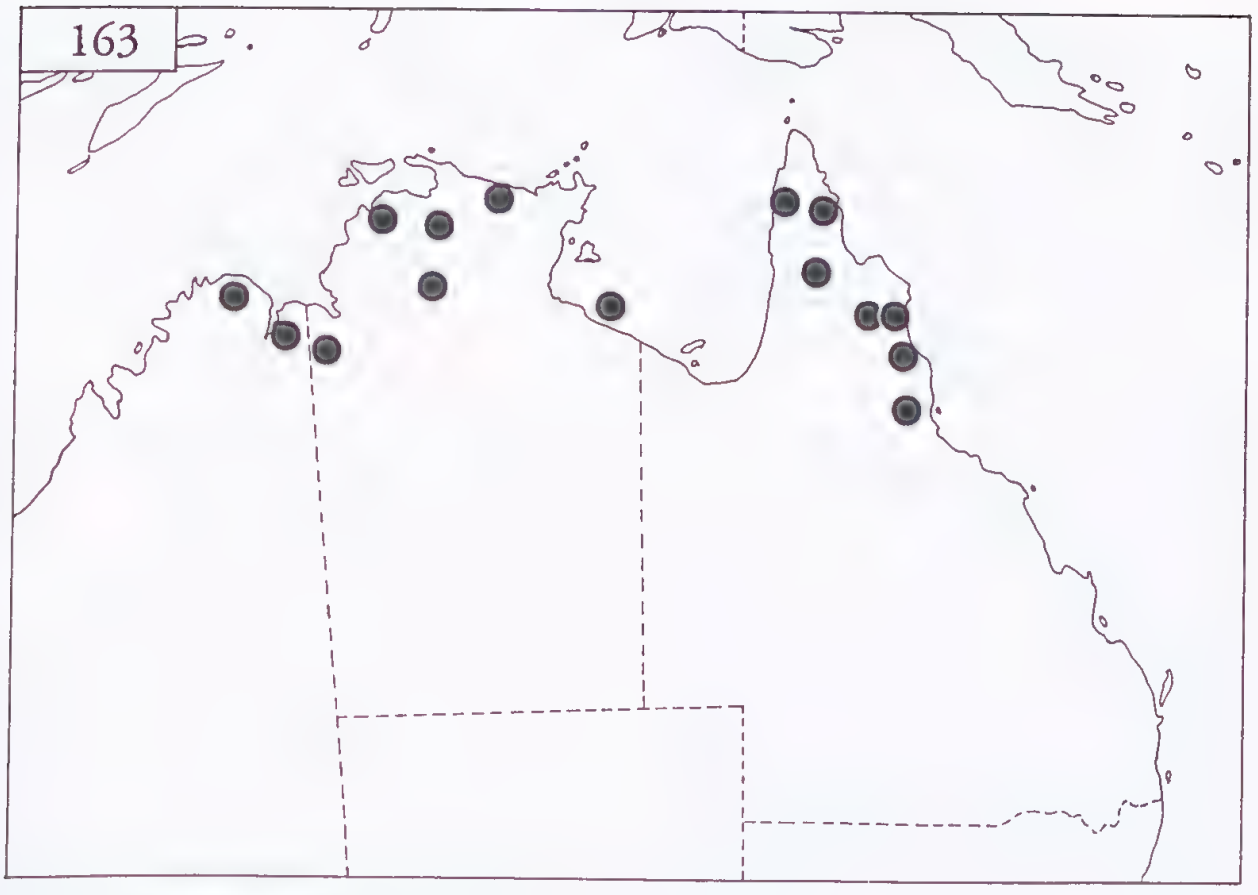


FIGURE 163. Distribution of *Haliplus alastairi*.

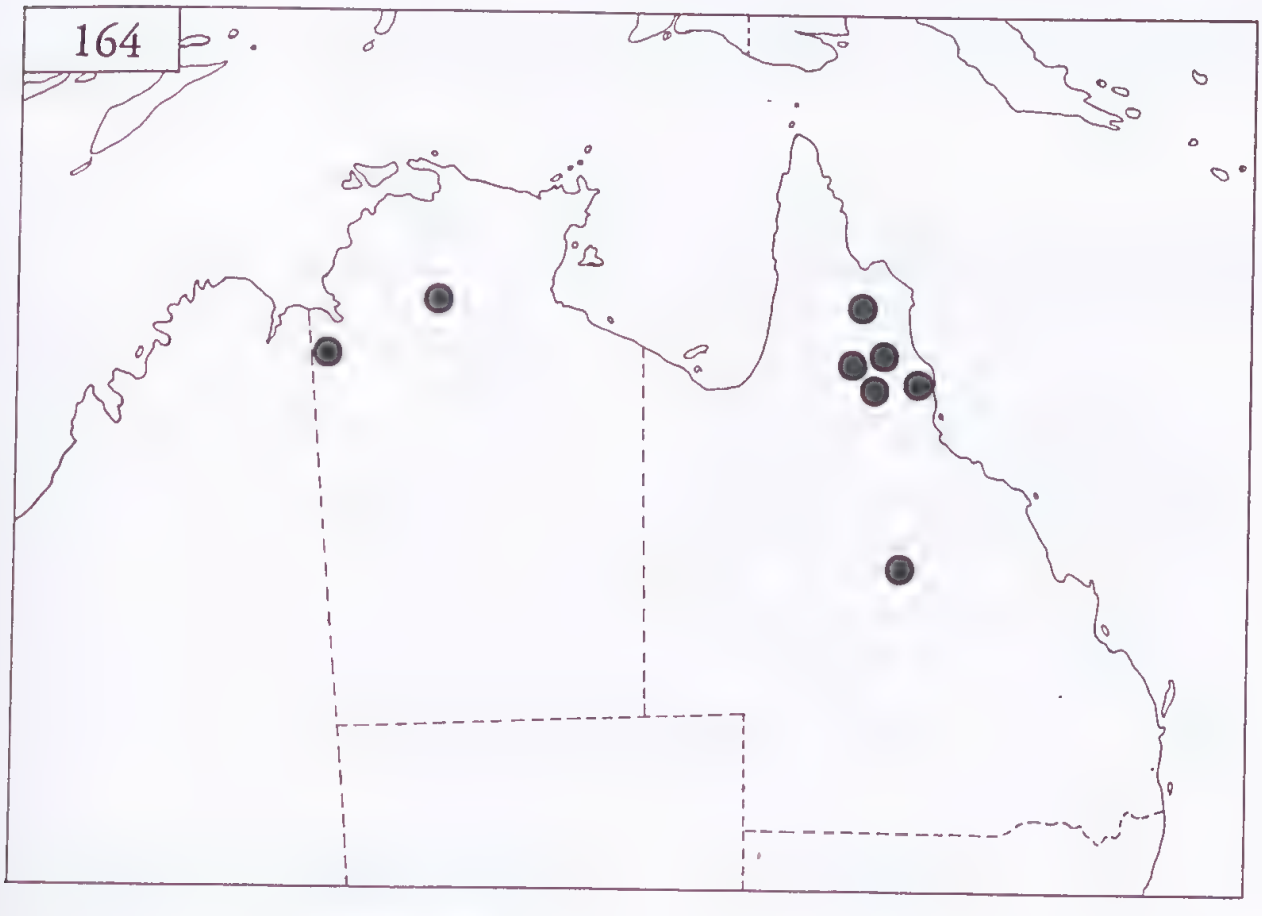


FIGURE 164. Distribution of *Haliplus timmsi*.

Elytra: Yellow to yellow-red. Primary punctures weak and sparse, row 1+2 not as strong as row 3–7, base of row 5 ending in transverse strong impression, about 25 punctures in row 1. Secondary punctures scattered and almost restricted to odd intervals, sutural row almost as strong, but not as dense as primary row 1 (Fig. 149). Punctures not darkened. Interval between puncture-row 8 and 9 slightly elevated in anterior part. Lateral sides margined and clearly serrate near shoulders and near apex.

Underside: Yellow to yellow-red, elytral epipleura yellow to yellow-red, legs yellow-red to yellow-brown, slightly darkened near coxae. Elytral epipleura reaching end of sternite 5. Prosternum completely margined anteriorly, not or hardly punctured. Prosternal process parallel-sided, slightly wider posteriorly, anterior edge margined, slightly impressed in posterior half, weakly punctured, stronger punctures in impression (Figs 151, 152). Metasternal process hardly wider than prosternal process, clearly impressed anteriorly, moderately strongly punctured (Fig. 151). Metacoxal lobes reaching to end of sternite 4, sparsely punctured, punctures weaker towards suture. Sternite 5+6 with complete puncture-rows, sternite 7 completely, but sparsely punctured. Setiferous striole on dorsal face of hind tibia short, with about 3 punctures, both tibial spurs about 2/3x length of first tarsal segment (Fig. 150).

Male: unknown

Distribution (Fig. 153)

Only known from type localities in Queensland: Bentinck Island (holotype) and Homehill (unexamined paratype).

Material examined: Only holotype ♀.

Acknowledgments

I am very grateful to Dr C. H. S. Watts (Adelaide, SAMA) for his very valuable help and to Dr D. J. Larson (St. John's, MUNC) and Dr O. Biström (Helsinki, UZMH) for critical comments.

I wish to express my sincere thanks to the following persons for placing material or information at my disposal: Dr L. Baert (Brussels, ISNB), Mr M. J. D. Brendell (London, BMNH), Dr S. P. Cover (Cambridge, MCZC), Dr K. Desender (Brussels, ISNB), Dr M. Hansen (Copenhagen, ZMUC), Dr S. J. Hine (London, BMNH), Dr M. Holmen (Copenhagen, ZMUC), Dr M. Jäch (Vienna, NHMV), Dr J. Krikken (Leiden, RMNH), Dr G. B. Monteith (South Brisbane, QMBA); Mrs H. Perrin (Paris, MNHN), Dr R. Poggi (Genoa, MCSN); Dr G. A. Samuelson (Honolulu, BPBM), Ms M. Schneider (Brisbane, UQIC); Dr A. Smetana (Ottawa, CNCI), Mr R. I. Storey (Mareeba, QPI); Dr R. zur Strassen (Frankfurt am Main, SMFD), Mr K. Walker (Abbotsford, MVMA); Mr T. A. Weir (Canberra, ANIC).

The Uyttenboogaart-Eliasen Foundation is acknowledged for financial support.

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MOLLUSC TYPE SPECIMENS IN THE SOUTH AUSTRALIAN MUSEUM. 6. ADDITIONS AND CORRECTIONS TO PART 1 (CEPHALOPODA AND SCAPHOPODA) AND PART 3 (POLYPLACOPHORA).

K. L. GOWLETT-HOLMES & W. ZEIDLER

GOWLETT-HOLMES, K. L. & ZEIDLER, W. 1995. Mollusc type specimens in the South Australian Museum. 6. Additions and corrections to Part 1 (Cephalopoda and Scaphopoda) and Part 3 (Polyplacophora). *Records of the South Australian Museum* **28**(1): 103–111.

This paper lists the recent additions made to the South Australian Museum's type collections of Chitons (Zeidler and Gowlett, 1986) and Cephalopoda (Zeidler and Macphail, 1978). Since publication of these type lists type material of twelve taxa of Polyplacophora and nine taxa of Cephalopoda have been added to the Museum's collections. Further additions to type material of species listed previously, changes in type status and nomenclature are also noted, reflecting the importance of the mollusc collection in the South Australian Museum.

K. L. Gowlett-Holmes and W. Zeidler, South Australian Museum, North Terrace, Adelaide, South Australia 5000. Manuscript received 18 October 1994.

There have been several important additions to the collections since the first publication in the series (Zeidler & Macphail, 1978) cataloguing the mollusc type specimens in the South Australian Museum (SAM). One of the most significant additions since then has been some historical cephalopod types described by S. Stillman Berry in 1921 and 1932, which until recently had been thought lost. These were found amongst Berry's vast collection, most of which was bequeathed to the Santa Barbara Museum of Natural History upon his death on 9 April 1984 (Hochberg, 1985), except for the cephalopod collection, which was left to the Smithsonian. Dr Clyde Roper subsequently curated Berry's cephalopod material and returned the specimens to the South Australian Museum in 1986. Two of the types had been out on loan for 65 years!

Other additions have resulted from subsequent work on the collections, donations from other workers and nomenclatural changes, reflecting the importance of the mollusc collection in the South Australian Museum. The types of 9 taxa of cephalopods and 12 taxa of Polyplacophora have been added to the SAM collections. There have been changes to the status or additions to the types of 7 taxa of Polyplacophora listed previously (Zeidler & Gowlett, 1986). There have been no additions to the gastropod families catalogued to date; Conidae (Zeidler, 1985), Marginellidae (Hewish & Gowlett-Holmes, 1991), Cypraeidae, Triviidae and Ovulidae (Gowlett-Holmes & Zeidler, 1993). In the following list species are arranged alphabetically in families under the original name at the time of description. In the Polyplacophora, specimens are dry unless otherwise indicated, and are listed as 'entire' when the articulated valves and girdle are present or as 'entire with animal' when the animal is also present.

Other abbreviations used in the text are as follows; AM = Australian Museum, Sydney. BMNH = The Natural History Museum, London (formerly British Museum, Natural History). LACM = Los Angeles County Museum of Natural History, California. MNHN = Museum National dHistoire Naturelle, Paris. NMNZ = Te Papa Tongarewa Museum of New Zealand, Wellington (formerly National Museum, New Zealand). NMV = Museum of Victoria, Melbourne (formerly National Museum of Victoria). QM = Queensland Museum, Brisbane. RSM = Royal Scottish Museum, Edinburgh. SBMNH = Santa Barbara Museum of Natural History, California. SEM = Scanning Electron Micrograph. USNM = National Museum of Natural History, Smithsonian Institution, Washington, DC. WAM = Western Australian Museum, Perth.

Class POLYPLACOPHORA

Family ABYSSOCHITONIDAE

Genus *Ferreiraella* Sirenko, 1988

Ferreiraella caribbensis Sirenko, 1988
Zool. Zh. **67**(12): 1778–81, figs 1, 2.

Paratype: D18762, one specimen with animal in spirit, with anterior and two median valves disarticulated, dredged in 6740–6780 m, Cayman Trench, Caribbean Sea [19°39'N, 76°37'W], RV 'Ac. Kurchatov', Stn 1267, collected by L. Moskalev, 24–5 March, 1973.

Note: Donated to SAM collections by B. I. Sirenko, St Petersburg, Russia. The holotype and additional paratypes are in the Academy of Sciences, St Petersburg, Russia.

Family ACANTHOCHITONIDAE

Genus *Acanthochites* Risso, 1826

Acanthochites kimberi Torr, 1912

Trans. R. Soc. S. Aust. **36**: 167, pl. 6, figs 5a–f.

= *Acanthochitona kimberi* (Torr, 1912).

Syntype: D17586, entire specimen with animal, from Aldinga, near Adelaide, South Australia, collected by W. J. Kimber, date of collection unknown.

Note: An additional syntype to the series listed by Zeidler and Gowlett (1986) found recently in the collections. Specimen with small label 'TYPE 59', typical of other Torr type specimens. Present status according to Kaas and Van Belle (1980).

Genus *Acanthochiton* Gray, 1821 em. Iredale, 1915

Acanthochiton mayi Ashby, 1922

Trans. R. Soc. S. Aust. **46**: 12, pl. 3, figs 1a–b.

= genus uncertain

Syntypes: D12799, five median valves, in 100 fm (183 m), 7 miles east of Cape Pillar, and from Schouten Island, Tasmania, collected by W. L. May, 18 Dec. 1907 (Cape Pillar). D17942, one median valve, in 60 fm (110 m), off Port Arthur, Tasmania, collected by W. L. May, date of collection unknown.

Note: May Collection No. 260A. Type status was not indicated on the original labels, but there is no doubt that these are the specimens that Ashby (1922) examined, and may include the valve he illustrated. Ashby states that one syntype was lodged with the Tasmanian Museum, but Turner and Dartnall (1971) do not list this specimen, and we have been unable tolocate it there. Kaas and Van Belle (1980) place this species in the genus *Notoplax*, but it does not fit into this genus as defined by Gowlett-Holmes (1991), and its current generic status is uncertain.

Genus *Acanthochitona* Gray, 1821

Acanthochitona saundersi Gowlett-Holmes & Zeidler, 1987

Trans. R. Soc. S. Aust. **111**(2): 111–4, figs 1, 2.

Holotype: D16699, entire specimen with animal, from on edge of granite slope, under sand, in 8 m, in cove off northwest point of East Franklin Island, Nuyts Archipelago, South Australia, collected by K. L. Gowlett, 20 July, 1983.

Paratypes: D16698, one specimen in spirit, disarticulated, valves and SEM stub of radula in dry collection, from on granite ledge, under sand, in 6 m, on inside of reef off southwest side of East Franklin Island, Nuyts Archipelago, South Australia, collected by K. L. Gowlett, 18 July, 1983. D17441, two entire specimens with animals, from on smooth rock under sand, in 12 m, on Far West Bottom, Tiparra Reef, Spencer Gulf, South Australia, collected by K. L. Gowlett, 13 May, 1982. D17475, one entire specimen with animal in spirit, from on granite fragment in sand pocket on reef, in 7 m, off Point Gilbert, Port Moorowie, Waterloo Bay, Yorke Peninsula, South Australia, collected by N. J. C. Holmes, 29 March, 1986.

Genus *Notoplax* Adams, 1861

Notoplax lancemilnei Gowlett-Holmes, 1988

Trans. R. Soc. S. Aust. **112**(4): 169–71, figs 1–3.

Paratype: D18436, entire specimen with animal in spirit, trawled by F. R. V. 'Kapala' in 439 m, off Wollongong, New South Wales [34°21–19'S, 151°23–25'E], collected by K. Graham, 13 December, 1978.

Note: Holotype in AM (C151130).

Family CHITONIDAE

Genus *Chiton* Linnaeus, 1758

Chiton (Rhyssoplax) kimberi Ashby, 1928

Trans. R. Soc. S. Aust. **52**: 170, pl. 12, figs 10–12.

= *Rhyssoplax kimberi* (Ashby, 1928)

Holotype: D12392, eight disarticulated valves, fragments of girdle, plus radula mounted on slide, from Capricorn Group, Queensland, collected by W. J. Kimber, date of collection unknown.

Note: This species was listed by Zeidler and Gowlett (1986). The three median valves listed there as presumed lost have now been located.

The two lots have been combined and registered under the one number, as the pieces all belong to the one specimen, the unique holotype..
This species was listed by Kaas and Van Belle (1980) as *Chiton (Rhyssoplax) kimberi*, but *Rhyssoplax* is now considered a valid genus (Bullock, 1988).

Chiton tulipa alfredensis Ashby, 1928
Proc. Malac. Soc. **18**(2): 87, pl. 8, figs 19–21.
= *Rhyssoplax tulipa* (Ashby, 1928)
Holotype: D10983, two slides, each with a piece of what appears to be a single radula, from Port Alfred, South Africa, collected by W. H. Turton, date of collection unknown.
Note: This material most likely belongs to the holotype listed by Zeidler and Gowlett (1986). This species was listed by Kaas and Van Belle (1980) as *Chiton (Rhyssoplax) tulipa*, but *Rhyssoplax* is now considered a valid genus (Bullock, 1988).

Family ISCHNOCHITONIDAE

Genus ***Ischnochiton*** Gray, 1847

Ischnochiton (Lepidozona) asthenes Berry, 1919
Lorquinia **2**(6): 47.
= *Callistochiton asthenes* (Berry, 1919)
Paralectotype: D10404, entire specimen, from White's Point, Los Angeles County, California, United States of America, collected by A. G. Smith, 14–18 July, 1916.
Note: This specimen was listed by Zeidler and Gowlett (1986) as a paratype, but as the primary type selection was made in a later paper (Berry, 1919b) than the original description, it is a lectotype, and the specimen in SAM is a paralectotype. Lectotype (34389) and additional paralectotypes (34390–2) in SBMNH.

Ischnochiton crebristriatus Cochran, 1988
Proc. R. Soc. Vic. **100**(1): 1–7, figs 1–4, tables 1, 2.
Holotype: D18405, entire specimen with animal, from on rocks and pebbles under sand, in 8 m, inside reef, southwest side of East Franklin Island, Franklin Islands, Nuyts Archipelago, South Australia, collected by K. L. Gowlett, 13 April, 1983.
Paratypes: D11774, one entire specimen with animal (crushed), from Port Willunga, near Adelaide, South Australia, collected by E. Ashby, date of collection unknown. D14482, one entire specimen with animal, from Arno Bay, Eyre Peninsula, South Australia, collected by B. J. Weeding, date of collection unknown. D16568, three entire specimens with animal, from on granite rocks under medium to coarse sand, in 10 m, big break north of islands, Franklin Islands, Nuyts Archipelago, South Australia, collected by K. L. Gowlett, 21 July, 1983. D16569, one entire specimen with animal, from on rock under sand, in 15 m, rise inshore of big break north of islands, Franklin Islands, Nuyts Archipelago, South Australia, collected by K. L. Gowlett, 24 February, 1983. D16570, two specimens, one entire with animal, one entire specimen and radula, from on smooth granite and pebbles under sand, in 6–11 m, between West Franklin Island and Seal Island, Franklin Islands, Nuyts Archipelago, South Australia, collected by K. L. Gowlett, 25 February, 1983. D16571, one specimen in spirit with posterior and two median valves disarticulated, radula and part of girdle on SEM stubs in dry collection, with same locality data as holotype, collected by P. Aerfeldt. D16572, three entire specimens with animals, with same collection data as holotype. D16573, one specimen with animal, with anterior, one median and posterior valves disarticulated, from edge of granite slope under sand, in 8 m, in cove, northwest point of East Franklin Island, Franklin Islands, Nuyts Archipelago, South Australia, collected by K. L. Gowlett, 20 July, 1983. D16574, two entire specimens with animals, from on granite rock under sand, in 6 m, inside cove west end of Seal Island, Franklin Islands, Nuyts Archipelago, South Australia, collected by K. L. Gowlett, 17 July, 1983. D18406, one entire specimen with animal, from near Port Hughes, Moonta Bay, Yorke Peninsula, South Australia, collected by B. J. Weeding, Jan. 1932.

Ischnochiton hewitti Ashby, 1931
Ann. S. Afr. Mus. **30**(1): 33–4, pl. 5, figs 50–53.
= *Ischnochiton bergoti* (Velàin, 1877)
Syntype: D10997, entire specimen, and radula mounted on slide, from Table Bay, Cape Town, South Africa, collector and date of collection unknown.
Note: Zeidler and Gowlett (1986) list this specimen as the holotype, but noted that it was probably only a paratype. However, as Ashby (1931) did not designate a type and used a series of specimens in the description, this specimen is a syntype. Current status according to Kaas and Van Belle (1990).

Ischnochiton (Chartoplax) nubilus Cochran, 1993

Proc. R. Soc. Vic. **105**(1): 51–4, figs 1, 2.

Holotype: D11728, entire specimen with animal, dredged from Gulf St Vincent, South Australia, collected by J. C. Verco, date of collection unknown.

Paratypes: D15127, one entire specimen, and radula on slide, dredged in 20 m, from off Brighton, near Adelaide, South Australia, collected by M. J. Tilbrook, 8 June, 1968. D17592, one entire specimen with animal in spirit, from on pebble in sand, in *Posidonia* seagrass, in 3 m, 150–200 m offshore of northwest point of Reevesby Island, Sir Joseph Banks Group, South Australia, collector W. Zeidler, 13 January, 1984. D17593, one specimen with animal in spirit, anterior, two median and posterior valves disarticulated, one valve, radula and part of girdle on SEM stubs in dry collection, from on pebbles in sand, in sparse *Posidonia* seagrass, in 3–6 m, off northwest point of Marum Island, Sir Joseph Banks Group, South Australia, collected by W. Zeidler and K. L. Gowlett-Holmes, 23 January, 1986.

Note: The holotype (D11728) is also the paralectotype of *Ischnochiton (Stenochiton) pallens* Ashby, 1900, also listed here. The slide of paratype D15127 contains two radulae, one of which is from the paratype, the other is from a non-type specimen (D14928).

Ischnochiton (Stenochiton) pallens Ashby, 1900

Trans. R. Soc. S. Aust. **24**: 86, pl. 1, figs 1a–e, g.

= *Ischnochiton (Chartoplax) purus* Sykes, 1896

Lectotype: D978, five disarticulated median valves and anterior valve, from Gulf St Vincent, South Australia, dredged by J. C. Verco, date of collection unknown.

Paralectotype: D11728, entire specimen with animal, with same collection data as lectotype.

Note: Zeidler and Gowlett (1986) incorrectly listed these specimens as holotype and paratype, following Cotton and Godfrey (1940) and Cotton (1964). However, Ashby (1900) did not designate a type for this species, although he labelled the specimens 'type' and 'co-type'. Cotton & Godfrey (1940) by listing D978 as a holotype, actually designated the lectotype by inference of holotype (ICZN Article 74(a & b)).

The paralectotype (D11728) is also the holotype of *Ischnochiton (Chartoplax) nubilus* Cochran, 1993, also listed here.

Genus ***Juvenichiton*** Sirenko, 1975

Juvenichiton komandorensis Sirenko, 1975

Zool. Zh. **54**(10): 1445–7, fig. 2.

Paratypes: D18761, two entire specimens with animals, from on *Constantinea subulifera* (a red alga), in 15 m, Cape Fedoskin, Bering Island, Commander Islands, Bering Sea, Russia, collected by B. I. Sirenko, 23 September, 1973.

Note: Donated to SAM collections by B. I. Sirenko, St Petersburg, Russia. The holotype and additional paratypes are in the Academy of Sciences, St Petersburg, Russia.

Genus ***Particulazona*** Kaas, 1993

Particulazona milnei Kaas, 1993

Basteria **57**: 127–30, figs 1–14.

Holotype: D18930, disarticulated and dissected, most valves and girdle fragments in vials, girdle and valve fragments on SEM stubs, girdle fragments and radula on slides, from on mangrove roots, Frances Bay, Darwin, Northern Territory, collected by M. J. Tilbrook, 22 July, 1954.

Note: Type unique.

Genus ***Stenochiton*** Adams and Angas, 1864

Stenochiton pilsbryanus dilatus Iredale & Hull, 1924

Aust. Zool. **3**: 287, pl. 36, fig. 11.

= *Stenochiton pilsbryanus* (Bednall, 1897)

Syntype: D18766, entire specimen with animal, from on blades of seagrass, Lucky Bay, 25 miles east of Esperance, Western Australia, collected by A. F. B. Hull, date of collection unknown.

Note: From the K. L. Milne Collection. Originally labelled as a paratype, but Iredale and Hull did not designate a holotype, so all type specimens constitute a syntype series. An additional syntype is in WAM (11658). Present status according to Kaas and Van Belle (1994).

Family LEPIDOPLEURIDAE

Genus ***Lepidopleurus*** Risso, 1826

Lepidopleurus badius Hedley & Hull, 1909

Rec. Aust. Mus. **7**: 260, pl. 73, figs 1, 2.

= *Leptochiton badius* (Hedley & Hull, 1909)

Paratype: D12532, one entire specimen with

animal, from Long Reef, near Narrabeen, New South Wales, collector and date of collection unknown.
Note: The other lot (D10668) listed by Zeidler and Gowlett (1986) as possible paratypes of this species, has since been confirmed not to represent type material.

Family MOPALIIDAE

Genus ***Placiphorina*** Kaas and Van Belle, 1994

Placiphorina gowlettholmesae Kaas & Van Belle, 1994
'Monograph of Living Chitons **5**: 341–3, fig. 138, map 39.
Holotype: D18837, entire specimen with animal in spirit, from under stones embedded in silty black sand, in 6–15 ft (2–4.5 m), Batu Belah (approximately 4 km west of Amed), Bali, Indonesia, collected by K. L. Gowlett-Holmes and W. Runti, 18 September, 1990.
Paratypes: D18838, one disarticulated specimen, and 9 entire specimens with animals in spirit, from under rocks embedded in silty black sand, in 6–10 ft (2–3m), at site of MV 'Liberty' shipwreck, Tulamben, Bali, Indonesia, collected by K. L. Gowlett-Holmes, 8 September, 1990.
Note: Additional paratypes with same data as D18838 are in the Nationaal Natuurhistorisch Museum, Leiden, Netherlands(RMNH 9357). The slides of the girdle and radula mentioned by Kaas and Van Belle (1994) have not been deposited in SAM.

Family SCHIZOCHITONIDAE

Genus ***Schizochiton*** Gray, 1847

Schizochiton polyops Iredale & Hull, 1926.
Aust. Zool. **4**: 271, pl. 38, figs 16, 17, 19–21.
= *Schizochiton incisus* (Sowerby, 1841).
Syntypes: D18767, two entire specimens, from Howick Island, Queensland, collected by A. F. B. Hull, date of collection unknown.
Note: From the K. L. Milne Collection. Originally labelled as paratypes, but Iredale and Hull did not designate a holotype, so all type specimens constitute a syntype series. Additional syntypes should exist in the AM and NMV, but none are listed by Smith and Robertson (1970) or Boyd and Phillips (1985), or in the computer printout of Polyplacophoran types in AM. Present status according to Kaas and Van Belle (1980).

Family XYLOCHITONIDAE

Genus ***Xylochiton*** Gowlett-Holmes and Jones, 1992

Xylochiton xylophagus Gowlett-Holmes & Jones, 1992
J. Malac. Soc. Aust. **13**: 38–43, figs 1–5.
Paratypes: D18770, three specimens, two entire with animal, one specimen disarticulated, in spirit, radula on SEM stub in dry collection, dredged in 1075–1100 m, on large waterlogged log of *Coriaria arborea* (Tree Tutu), off White Island [37°23.7'S, 171°39.5–36.6'E], east of North Island, New Zealand, collected by the U.S.S.R. FV 'Kalinovo', Stn BS 924 (K01/019/81), 23 November, 1981.
Note: The holotype (M.100855) and additional paratypes (M.74996, M.84251, M.86822, M.92446) are in NMNZ. Additional paratypes are in RSM (NMSZ 1991055), USNM (860288), BMNH (1991145), AM (C168568), MNHN and LACM (2280).

Class CEPHALOPODA

Family IDIOSEPIIDAE

Genus ***Idiosepius*** Steenstrup, 1881

Idiosepius notoides Berry, 1921
Rec. S. Aust. Mus. **1**(4): 361–2, chart 11, fig. 67.
Holotype: D17495, complete male specimen in spirit, from Goolwa, South Australia, collected by A. Zeitz, date of collection unknown (Berry Collection No. SSB 719).
Note: Paratype female in USNM (SSB 720).

Family SEPIOLIDAE

Genus ***Neorossia*** Boletzky, 1971

Neorossia leptodons Reid, 1991
Bull. Mar. Sci. **49**(3): 797–806, figs 14d, 24–28, tables 23,24, appendix 1d.
Paratypes: D18632, one complete female in spirit, trawled in 130 m, approx. 80 nautical miles south–southwest of St Francis Island, Nuyts

Archipelago, South Australia, [33°42'S, 132°25'E] FV 'Merindah Pearl', collected by M. Jubb, 12 August, 1988. D18724, one complete female in spirit, trawled in 1000 m, approx. 120 nautical miles southwest of Cape Adieu, Great Australian Bight, South Australia, [33°58'S, 131°22'E], FV 'Saxon Progress', collected by D. Wheenan, Nov. 1989. D18725, one complete male in spirit, same collection data as D18724. D18726, three complete males in spirit, same collection data as D18724.
Note: Holotype (F57504) and additional paratypes are held in NMV, and additional paratypes are held in AM.

Family SEPIADARIIDAE

Genus ***Sepiadarium*** Steenstrup, 1881

Sepiadarium austrinum Berry, 1921
Rec. S. Aust. Mus. **1**(4): 354–5, chart 10.
Holotype: D17493, complete male specimen in spirit, from Gulf St Vincent, South Australia, collected by A. Zeitz, September, 1885 (Berry Collection No. SSB 716).
Paratype: D17494, complete female specimen in spirit, same collection data as holotype (Berry Collection No. SSB 718).
Note: Paratype in USNM (SSB 717).

Sepiadarium nipponianum Berry, 1932
Philippine J. Sci. **47**(1): 42–6, pl. 1, figs 2–5.
Paratype: D17496, complete specimen in spirit, from Sagami Bay, Japan, collector M. Sasaki, 10 April, 1918 (Berry Collection No. SSB 725).
Note: Holotype in USNM (SSB 724).

Family OCTOPODIDAE

Genus ***Eledone*** Leach, 1817

Eledone palari Lu & Stranks, 1991
Bull. Mar. Sci. **49**(1–2): 73–85, figs 1–6.
Paratypes: D18721, one male and one female, both complete in spirit, trawled in 157 m, east of North Stradbroke Island, Queensland, [27°35'S, 153°50'E], FV 'Iron Humphrey', collected by M. Potter, 2 July, 1981, (ex NMV F57531).
Note: Holotype (F57849) and additional paratypes in NMV, additional paratypes in AM, WAM and QM.

Genus ***Octopus*** Lamarck, 1798

Octopus berrima Stranks & Norman, 1993
Mem. Mus. Vic. **53**(2): 355–61, figs 3, 6–11.
Paratype: D18775, dissected male specimen in spirit, dredged off Mordialloc, Port Phillip Bay, Victoria, [38°02'S, 145°05'E], FV 'A. B. Hunter II', 25 September, 1984 (ex NMV F52510).
Note: Holotype (F67132) and additional paratypes in NMV and an additional paratype in AM.

Octopus bunurong Stranks, 1990
Mem. Mus. Vic. **50**(2): 462–4, figs 3a–f.
Paratypes: D17983, one complete male specimen in spirit, from reef, rubble, sand and *Posidonia* seagrass, in 6 m, Partney Shoal, west of Partney Island, Sir Joseph Banks Group, South Australia, collected by W. Zeidler and N. J. C. Holmes, 21 January, 1986. D17986, one complete male specimen in spirit, from 50 m offshore of Marino Rocks, near Adelaide, South Australia, collected by R. Browne, 28 January, 1982.
Note: Holotype (F53223) and additional paratypes in NMV.

Octopus kaurna Stranks, 1990
Mem. Mus. Vic. **50**(2): 460–2, figs 2a–f.
Paratypes: D13283, one complete immature male specimen in spirit, from off Brighton, near Adelaide, South Australia, collected by W. G. Hollis, September, 1937. D16195, one female specimen in spirit, and radula on slide, from off Glenelg, near Adelaide, South Australia, collected by A. E. Robb, 29 March, 1949.
Note: Holotype (F24494) and additional paratypes in NMV.

Octopus warringa Stranks, 1990
Mem. Mus. Vic. **50**(2): 457–60, figs 1a–f.
Paratype: D15219, complete female specimen in spirit, from off Maria Island, Tasmania, [42°40'S, 148°28'E], RV 'Discovery', BANZARE Stn 113, 23 March, 1931.
Note: This specimen was originally identified as *Robsonella australis* (Hoyle, 1885) by Dell (1959). Holotype (F57444) and additional paratypes in NMV, and an additional paratype in AM.

ACKNOWLEDGMENTS

We are most grateful to Dr. Clyde Roper, USNM for ensuring the safe return of the cephalopods described by

S. S. Berry and to Dr. Boris Sirenko, Academy of Sciences, St. Petersburg, Russia for donating chiton paratypes.

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REVISION OF THE AUSTRALASIAN GENERA *AGRAPHYDRUS* REGIMBART, *CHASMOGENUS* SHARP AND *HELOCHARES* MULSANT (COLEOPTERA: HYDROPHILIDAE)

C. H. S. WATTS

WATTS, C. H. S. 1995. Revision of the Australasian genera *Agraphydrus* Régimbart, *Chasmogenus* Sharp and *Helochares* Mulsant (Coleoptera: Hydrophilidae). *Records of the South Australian Museum* **28**(1) 113–130.

The Australian and New Guinean members of the Hydrophilid genera *Agraphydrus*, *Chasmogenus* and *Helochares* are revised and redescribed. A key to the genera and species is given. Fourteen species are recognised of which six are described as new: *H. (Hydrobaticus) marreensis; H. (Hydrobaticus) percyi; H. (Hydrobaticus) anthonyae; H. (Hydrobaticus) thurmerae; H. (Hydrobaticus) loweryae;* and *H. (Hydrobaticus) dalhuntyi. H. (Hydrobaticus) australis* Blackburn is synonymised with *H. (Hydrobaticus) tristis* Macleay. *H. (Hydrobaticus) luridus* W. Macleay is resurrected from synonymy with *H. tristis* W. Macleay.

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Manuscript received, 25 May 1994.

The three genera under discussion are small aquatic Hydrophilidae belonging to the tribe Hydrophilini, subtribe Acidocerina, which are characterised by lack of a sternal keel, head not strongly deflexed, middle and hind tibiae without swimming hairs, maxillary palpi larger than antennae and with pseudobasal segment, straight or curved, with convexity on inside, and the mesosternum without projecting longitudinal laminae. Until recently they were all included in the genus *Helochares* Mulsant, 1844 but were reinstated as full genera in the extensive revision of the Hydrophiloids by Hansen (1991).

As well as Australia and New Guinea, species of *Helochares* are widespread in both the old and new world, *Chasmogenus* Sharp, 1882 in Neotropical, Oriential and Palearctic regions and *Agraphydrus* Régimbart, 1903 in East Africa, Southern Asia and Japan.

D'Orchymont (1925, 1939, 1943) revised *Chasmogenus* and *Helochares*, including all the Australian and New Guinean species then known. The genera and various subgenera of the group are readily recognised but within them the species are difficult to distinguish. D'Orchymont noted that in *Chasmogenus* the characters of the aedeagus are the only reliable means of separating species. I have found this to be true for several *Helochares* species also.

Specimens of *H. (Hel.) foveicollis* (Montrouzier, 1860) and *C. nitescens* Fauvel, 1883 are often mistaken for species of *Enochrus* Thomson, 1859 but can be separated by the maxillary palps having the pseudobasal segment bent inwards in *Helochares* and *Chasmogenus* rather than outwards as in *Enochrus*. *Helochares* and *Chasmogenus* also lack the simple protuberance in the ventral midline in front of the mesocoxae present in *Agraphydrus*.

Within *Helochares*, eleven of the twelve Australian species belong to the subgenus *Hydrobaticus* W. MacLeay, 1871, which is readily recognised by its strongly punctate surface with distinct striae or rows of punctures on elytra. All but one species (*H. anchoralis* Sharp, 1890) are endemic to the region and only two are known from both New Guinea and Australia. In contrast, the subgenus *Helochares* lacks strong sculpture and is represented, in Australasia, by a single species which is also widespread in South-east Asia and the Pacific Islands. The single Australasian species of *Agraphydrus* and *Chasmogenus* are tropical with a wide distribution in South-east Asia as well as Australasia.

Most species in the group are tropical but one *H. (Hyd.) tristis* Macleay, 1871, is common in southern Australia and another *H. (Hyd.) tenuistriatus* Régimbart, 1908 is found only in the south-west of Western Australia.

All species are inhabitants of shallow still water or slow moving well-vegetated streams. Females of *H. (Hyd.) tristis* are often taken with a large white coloured eggmass attached to the ventral surface of the abdomen. The larvae of *H. tristis*

and *C. nitescens* have been described by Anderson (1976) but I know of no studies of the ecology of any Australasian species.

Hansen (1991) provides a comprehensive taxonomic discussion of these genera, including detailed generic description and phylogenetic analysis.

The collections from which specimens were examined are listed under the following abbreviations:

AM	Australian Museum, Sydney
ANIC	Australian National Insect Collection
BELG	Institut royal des sciences Naturelles de Belgique, Bruxelles
BM(NH)	Natural History Museum, London
CW	Private collection of author
FIELD	Field Museum of Natural History, Chicago
MNHN	Museum National d'Histoire Naturelle, Paris
NMV	Museum of Victoria
NTM	Northern Territory Museum
QDPIM	Queensland Department of Primary Industries, Marreba
QM	Queensland Museum, Brisbane
SAMA	South Australian Museum, Adelaide
UQIC	University of Queensland Insect Collection, Brisbane
WAM	Western Australian Museum, Perth

Systematics

The genera *Agraphydrus*, *Chasmogenus* and *Helochares* can be separated from other Hydrophilids by the following characters: Head not strongly deflexed; scutellum not, or not much longer than its basal width; meso- and metatibia without swimming hairs. Antennae with eight or nine segments, maxillary palpi elongate, longer than antennae, last segment shorter than penultimate. Mesosternum without projecting carina in midline. Meso- and metasterna without a continuous keel. Elytra not strongly carinate. Curved basal joint of maxillary palpus with convexity at front.

Generic and subgeneric diagnoses are given in the key. More extensive generic diagnoses are given by Hansen (1991).

Key To Australasian Species Of *Agraphydrus* Régimbart, *Chasmogenus* Sharp And *Helochares* Mulsant

1 — Small size (< 3 mm); head predominantly black; pronotum and elytra yellow-brown; elytra sparsely punctured, punctures not in stria. Male genitalia relatively simple; aedeagus divided into upper and lower sections (Figs 13 & 14) ..... *Agraphydrus coomani* d'Orchymont

— Not with above combination of characters 2

2 — Black. Elytral striae virtually lacking, at most reduced to a few lines of serial punctures.....3

— Predominately brown. Each elytron with 10 complete striae. *Helochares*, subgenus *Hydrobaticus*.....4

3 — Smaller (< 5.0 mm). Sutural stria strongly impressed in at least apical half of elytra. Dorsal surface weakly punctured, punctures on head smaller than eye facets, subobsolete on scutellum ....*Chasmogenus nitescens* Fauvel

— Larger (> 6.0 mm). No sutural stria. Dorsal surface with well marked punctures, those on head larger than eye facets. Scutellum with sharply impressed punctures .....*Helochares sensu stricto H. foveicollis* (Montrouzier)

4 — Punctures on pronotum of uniform size except for small punctures close to front margin (Fig. 18).....8

— Punctures on pronotum of two sizes (Fig. 19).....5

5 — Numerous large punctures on front of head, particularly laterally, not greatly different in size and density to those on rest of head.....6

— Punctures on centre of head small, with only a few scattered larger ones, larger and more numerous laterally and on back half of head (Fig. 17). Large and small punctures on pronotum and in elytral interstriae very different in size (Fig. 19) .....*H. clypeatus* Blackburn

6 — Strial punctures close, often confluent and tending to form grooves, interstrial areas raised towards apex accentuating grooves (Fig. 23). (Punctures on elytron margin

strong at front grading to weak apically.) Male genitalia as in Fig. 5..... .....*H. luridus* Blackburn

— Strial punctures for most part not confluent and not forming grooves except toward apex to slight degree in some specimens (Fig. 22).....7

7 — Male genitalia as in Fig. 4. Most of the smaller interstrial punctures more than ½ diameter of larger ones ....*H. tenuistriatus* Régimbart

— Male genitalia as in Fig. 3. Most of the smaller interstrial punctures less than $^1/_3$ diameter of the larger ones (Fig. 20) .....*H. tristis* Macleay

8 — Punctures on head smaller than size of eye facets. (Serial punctures relatively small, confluent, forming grooves. Body size 5.5–6.2 mm.) Flanges of elytra with large punctures much larger than those in interstriae. Only known from New Guinea .....*H. anchoralis* Sharp

— Punctures on head larger than eye facets (except in *H. anthonyae*, a species with serial punctures on elytral disc not confluent). Punctures on flanges of elytra, other than in *H. tatei*, a much smaller species (body size 3.4–4.8 mm), usually smaller than those in adjacent interstriae..9

9 — Interstrial punctures at base of elytra (and often over rest of elytra as well) large, equal in size to the serial punctures which are also relatively large ....*H. marreensis* sp. nov.

— Interstrial punctures on elytra smaller than those in elytral stria (Fig. 21). Punctures in elytral stria also tend to be small (large in *H. tatei*).....10

10 — Punctures on head and pronotum very large, most about a quarter puncture width apart or less (Fig. 18). Number of punctures along midline of pronotum more than 30. Flattish species with elytra broadly and weakly flanged, somewhat truncate apically. Body length relatively large (> 4.8 mm) .....*H. percyi* sp. nov.

— Punctures on head and pronotum small to medium, many separated by half puncture width or more (except in some *tatei*). Punctures on pronotum larger laterally. Number of punctures along midline of pronotum 20–40.....11

11 — Number of punctures along midline of pronotum around 25. Punctures in elytral striae as large or larger than those on pronotum, interstrial punctures tend to increase in size laterally even prior to lateral fringe. Interstrial punctures between stria 8 and 9 usually in single line. Body length relatively small (<4.8 mm).....*H. tatei*

— Number of punctures along midline of pronotum around 35. Other characters usually not as above.....12

12 — Strial punctures in inner few rows diminish in size down apical declivity. (Distance between stria apically greater than 2 puncture widths apart. Surface of elytra towards apex has a very flat appearance).....*H. anthonyae* sp. nov.

— Strial punctures in apical quarter, apart from last few, do not diminish in size and may even increase in size.....13

13 — Lateral stria with 30 or fewer punctures. (Strial punctures relatively large.) ....*H. thurmerae* sp. nov.

— Lateral stria with more than 30 punctures .....*H. loweryae* sp. nov. .....or *H. dalhuntyi* sp. nov.

Agraphydrus Régimbart

Type species: Agraphydrus punctatellus Régimbart, 1903, Madagascar. Designation by monotypy.

Agraphydrus coomani (d'Orchymont)

Helochares (Agraphydrus) coomani d'Orchymont, 1927

Description (number examined 51)

Length 1.4–2.6 mm. Narrowly oval, head broad in front giving it a blunt-nosed appearance. Yellow-brown. Head black except laterally in front of eyes, disc of pronotum and elytra variably darker, tips of maxillary palpi black, underside dark brown except for yellow-brown appendages. Front of head broadly and weakly concave, sparsely covered by weakly impressed small punctures. Pronotum and elytra weakly reticulate, sparsely covered with small weakly impressed punctures, those on elytra more strongly impressed laterally. A number of barely traceable lines of serial punctures on each elytron. Maxillary palpi

relatively short and stout, apical segments a little larger than penultimate, basal segments a little larger than apical. Rugose portions of femur covering all but about apical quarter. Tibia with several rows of strong spines. Metacoxae and abdominal segments quite densely covered by well marked punctures, much stronger and denser than those on dorsal surface. Apical sternite weakly notched apically. Midline of metacoxae shining apically. Midline of metasternum very weakly and broadly ridged.

Male: Protarsi and claws a little stouter than in female; claws on protarsi more strongly recurved than in female. Aedeagus as in Figs 13 and 14.

Types

Holotype: Not located in d'Orchymont collection BELG. Type locality, Lactho near Hoa Binh, Tonkin, Vietnam.

Distribution (Australasian only)

Northern Territory

Cooper Creek, ANIC; 14 km NW Cape Crawford, ANIC; McArthur River, ANIC; Pine Creek, CW; Yuendumu, CW.

Queensland

16°28'S, 144°46'E, ANIC; Bushy Creek, Julatten, ANIC; Charters Towers, CW; 75 km Cooktown, ANIC; Mary Creek, ANIC; Mossman, Mt Lewis Road, ANIC; Mulgrave, ANIC.

New South Wales

Armadale, CW; Cabbage Tree Creek, ANIC.

Western Australia

Millstream, ANIC; 5 km SE Millstream, ANIC.

Papua New Guinea

Kokoda, BELG

Remarks

This small species is relatively common in collections from northern Australia. These specimens agree well with d'Orchymont's detailed description and with specimens, I take to be of this species, from Lenggong Malaya Peninsula in SAMA. There is a male specimen in BELG mounted on a card with genitalia extruded labelled as 'Papua: Kokoda 1 200 ft. VIII. 1933. L. E. Cheesman, B.M. 1933–577', 'Paratype', 'Borona laevigata, M. J. Balfour-Browne det'. 'A. d'Orchymont, det., *Helochares* (*Agraphydrus*) *laevigatus*. J. Balf.-Browne'. I can find no reference in the literature to this name and assume it is an unused name.

Chasmogenus Sharp, 1882

Type species: *Chasmogenus fragilis* Sharp, 1882, Central America; designation by monotypy.

Chasmogenus nitescens (Fauvel)

Philydrus nitescens Fauvel, 1883
Enochrus nitescens (Fauvel, 1883); Knisch 1924
Helochares (Crephelochares) nitescens (Fauvel, 1883); d'Orchymont 1939

Description (number examined 161)

Length 2.5–5.0 mm. Narrowly oval. Black. Clypeus, edges of pronotum, lateral margins of elytra often reddish, appendages testaceous. Front edge of head broadly and shallowly concave, a weak notch in front margin of head in some specimens. Dorsal surface with small weakly impressed well-separated punctures. In addition a few larger punctures in row across front of head and between front edges of eyes and pronotum with two fields of larger punctures on either side of midline towards front and a field of a few larger ones on each side in middle; each elytron with three or four ill-defined rows of well separated large serial punctures. Each elytron with sharply impressed sutural stria in apical half to three quarters, diverging somewhat toward front close to suture apically. Scutellum lacking punctures or with a few weak ones. Maxillary palpus long, slender, apical segment about two-thirds length of penultimate, first and second segments subequal. Femur with rugose portion covering all but small portion near apex. Coxal plates seemingly impunctate, but rugose and moderately covered with setae rather as on femurs, bare shiny area in midline apically. Abdominal sternites similarly sculptured; a well-developed but relatively low metasternal keel present. Apex of apical abdominal segment with small notch. Aedeagus as in Fig. 15, although there is considerable variation among the specimens examined.

Types

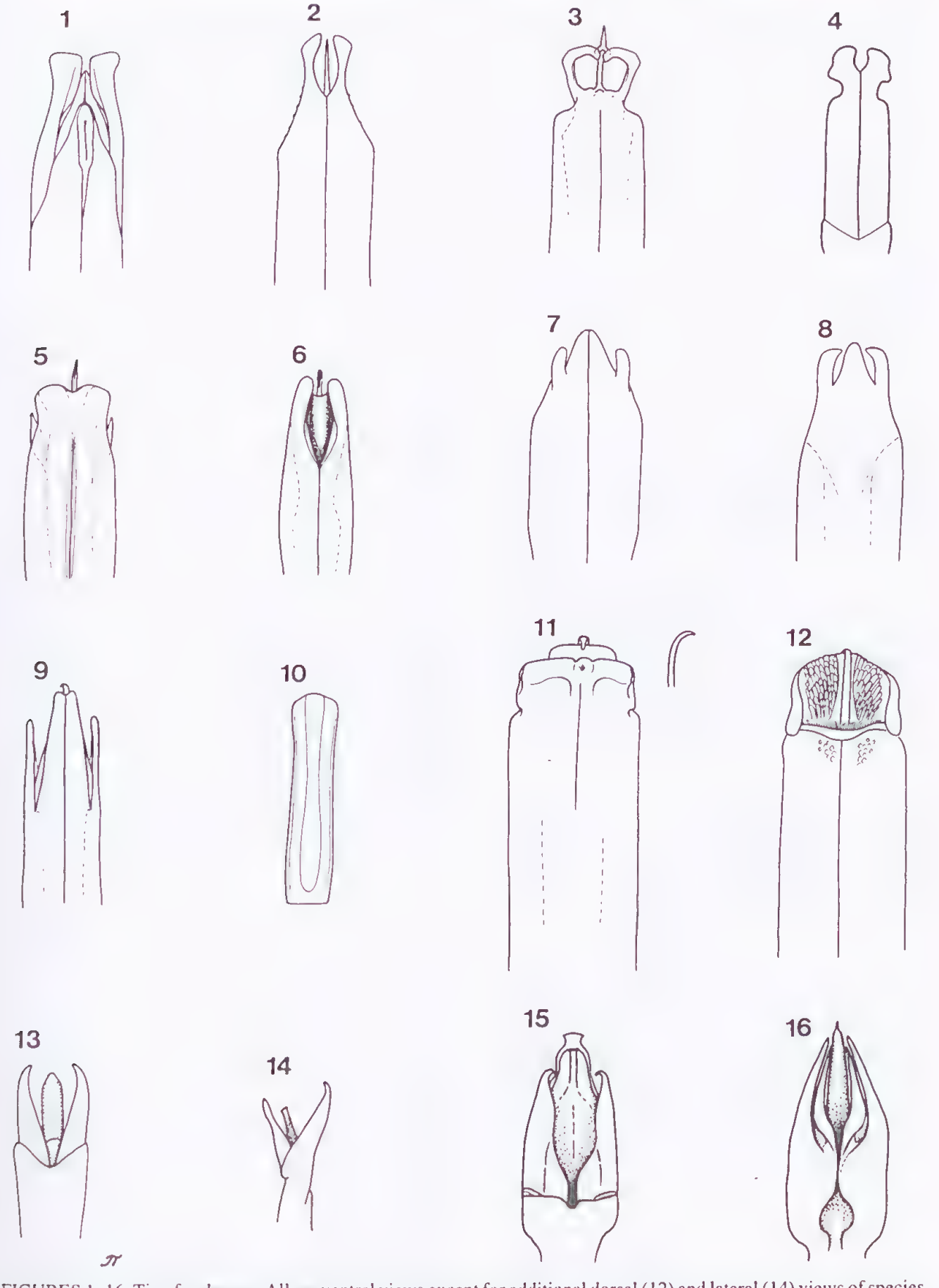
Lectotype male: 'Anse Vata – marass d'eau douce – août – savés, 'Nouvelle Caledonie', bearing original det label. 'Philhydrus nitescens Fvl', in BELG, herein designated.

Paralectotypes: 3, – same data as lectotype, in BELG, herein designated.

Distribution

Northern Territory

Black Point, Coburg Pen., ANIC; Katherine, ANIC; 8 km N Mt Cahill, ANIC; 19 km NE by E



FIGURES 1–16. Tip of aedeagus. All are ventral views except for additional dorsal (12) and lateral (14) views of species as follows; **1** *H. anthonyae*; **2** *H. clypeaus*; **3** *H. tristis*; **4** *H. tenuistriatus*; **5** *H. luridus*; **6** *H. tatei*; **7** *H. loweryae;* **8** *H. dalhuntyi*; **9** *H. thurmerae;* **10** *H. percyi*; **11** *H. anchoralis*; **12** *H.anchoralis*; **13** *A. coomani*; **14** *A. coomani*; **15** *C. nitescens*; **16** *H. foveicollis.*

Mt Cahill, ANIC; Nourlangie Creek, ANIC; 6 km SW by S, Oenpelli, ANIC.

Queensland

Ayr, ANIC; 5 ml [8 km] N Bloomfield River, ANIC; Cairns, BELG; Cape Tribulation, ANIC; 3 km S by W Cooktown, Mission Beach, ANIC; Giru, ANIC; Hann River, N. Laura, QDPIM; Innisfail, ANIC; 7 km NE Innisfail, ANIC; Mt Webb National Park, ANIC; Townsville, ANIC; 3 km ENE Mt Tozer, ANIC; 9 km ENE Mt Tozer, ANIC; 11 km ENE Mt Tozer, ANIC; 5 km W by N Rounded Hill, ANIC; 9 km SE Yeppoon, ANIC.

New South Wales

Yuragin, NP, ANIC.

Papua New Guinea

Lae, BMNH; 7 ml [11 km] Lae-Bulolo Road, BMNH; Gusap Markham Valley, ca 90 ml [145 km] W of Lae, BMNH.

Remarks

I have examined type material of *C. abnormalis* (Sharp, 1890), *C. simulator* (Kuwert, 1922), *C. livicornis* (Kuwert, 1889), *C. ferrugatus* (Régimbart, 1903) and *C. nigritulus* (Régimbart, 1903) and consider the Australian specimens to differ from all of these. This appears to be the only *Chasmogenus* in Australia.

Helochares Mulsant, 1844

Helochares Mulsant, 1844
Hydrobaticus W. Macleay, 1871
Neohydrobius Blackburn, 1898

Type species: Hydrobaticus: *Hydrobaticus tristis* W. Macleay, 1871, Gayndah, Queensland; designation by d'Orchymont (1943). *Helochares*: *Dytiscus lividus* Forster, 1771, Europe. *Neohydrobius*: *Philhydrus burrundiensis* Blackburn, 1890, Northern Territory, Australia; designation by Blackburn (1890).

Subgenus *Helochares*

Helochares (Helochares) foveicollis (Montrouzier)

Stagnicola foveicollis Montrouzier, 1860
Philhydrus burrundiensis Blackburn, 1890; syn. nov. *Neohydrobius burrundiensis* (Blackburn, 1890), Blackburn 1889; syn. nov. *?Helochares atropiceus* Régimbart, 1903
Helochares (Helochares) foveicollis (Montrouzier, 1860); Knisch 1924; d'Orchmont 1943
Helochares (Helochares) burrundiensis (Blackburn, 1890); Knisch 1924; syn. nov.

Description (number examined 356)

Length 6.1–8.2 mm. Broadly oval. Black. Front edge of head, margins of pronotum, lateral margins of elytra and apical portions of appendages testaceous. Front edge of head sinuate. Head and pronotum with small to medium sized (for genus) punctures, well impressed, separated by about width of a puncture. Punctures on side of head a little stronger and denser. Punctures on elytra same size or somewhat smaller than those on pronotum and a little sparser, particularly towards sides and apex. A sparse row of serial punctures traceable in about middle of each elytron and another weaker row near lateral margin. Maxillary palpus long, slender, second segment largest, apical segment about two-thirds length of middle one. Femur with rugose portion covering all but small portion near apex. Coxal plates sparsely and weakly punctured, covered in moderately impressed fine reticulation. Sternites shiny, covered with relatively sparse, small setose punctures; apex of apical sternite with small notch. Weak to well developed metasternal keel, highest apically.

Male: Aedeagus as in Fig. 16. Protarsi enlarged. Claws on protarsi strongly recurved, inner one with large scale-like vertical expansion at its base; claw on mesotarsi similar in shape but not quite as developed.

Female: Protarsi about two-thirds size of male's, claws simple; mesotarsi a little smaller than in male, claws simple.

Types

P. burrundiensis: Syntypes: 1 in BM(NH) 'T 2769' 'Philhydrus burrundiensis, Blackb.' with BM(NH) Type and Blackburn coll 1910–236 labels. 1 'NT, N. Territory', `Neohydrobius burrundiensis Blackb., Co-type', in SAMA, 1 'Philhydrus burrundiensis, Bl'. Co-type, in SAMA.

I am uncertain of the status of these types. The BM(NH) specimen is without locality label but is mounted on a card with a black 'T' and a red number in typical Blackburn style and carries the species label in Blackburn's handwriting. I have little doubt that this was meant as the holotype.

The first presumed syntype in SAMA fits Blackburn's style, except for his use of *Neohydrobius* as the generic name which was not described until nine years later by Blackburn (1898). The second presumed syntype in SAMA bears a single label not in Blackburn's hand. At some stage this specimen was remounted upside down. In his 1898 publication, Blackburn mentions original specimens. I am inclined to believe that all three specimens are part of the original series and that the two SAMA specimens were re-examined and relabelled when Blackburn described *Neohydrobius*. I nominate the BM(NH) specimen as lectotype and the two SAMA specimens as paralectotypes.

S. foveicollis: Not located. The type is supposedly in the Bedel Collection in MNHN but cannot be found there or in other collections in MNHN (Y. Cambefort in litt.). A specimen in MNHN from New Caledonia appears identical to Australian specimens and it is on this basis that I synonymise the species. d'Orchymont (1943) came to the conclusion, based on very limited material, that the two forms were very close and probably conspecific.

H. atropiceus Régimbart. Syntypes. 2 in MNHN seen. This New Guinean species appears to me to be very similar if not conspecific with *H. foveicollis*. According to d'Orchymont (1943) it is a junior synonym of *H. taprobanicus* (Sharp, 1890) from Ceylon and differs from *H. foveicollis* by its sculpture and male genitalia. I have not, however, looked closely at these non-Australasian forms and prefer to leave the question of whether or not they are conspecific open at the moment.

Distribution

Northern Territory

3.2 km S Adelaide River, ANIC; Alligator River, MV; Black Point, Coburg Pen., ANIC; Borroloola, ANIC; 22 km WSW Borroloola, ANIC; 5 km NNW Cahills Crossing, ANIC; 8 km ESE Cape Crawford, ANIC; Cooper Creek, ANIC; Darwin, SAMA, CW; 96.5 km S Darwin, ANIC; Edith River, ANIC; Elcho Island, ANIC; Holmes Jungle, ANIC; Horn Islet, Pellew Group, UQIC; Humpty Doo, QDPIM; Katherine, ANIC; Koongarra, ANIC; Magela Creek, ANIC, SAMA; Mataranka, ANIC; McArthur River, ANIC; Melville Island, ANIC; 10 km E by N Mt Cahill, ANIC; Nabarlek Dam, ANIC; Nourlangie Creek, SAMA; Pine Creek, CW; Rimbija Island, ANIC; Roper River, ANIC; South Alligator River, ANIC; Tindal, ANIC.

Queensland

Ayr, ANIC; Bamaga, ANIC, UQIC; Bentinck Is., SAMA; Burnett River, ANIC; Cairns, SAMA; Cape Tribulation, QM; Cardstone, ANIC; Carnarvon Range, AM; Clermont, AM; 19.3 km WNW Cooktown, ANIC; 40 km N Cooktown, ANIC; 50 km N Cooktown, QM; Cow Bay, QDPIM; Darwin, CW; E Alligator, AM; Green Hills, ANIC; Home Hill, CW; 7 km N Hope Vale Mission, ANIC; Innisfail, AM, SAM; Iron Range, ANIC, AM; 15 km W Irvinebark, ANIC; Kirrama, ANIC; 75 km NW of Laura, QDPIM; Mackay, MV; 80 km S Mackay, UQIC; Mission Beach, UQIC; Mornington Is. Mission, SAMA; 5 km ESE Mt Finnigan, ANIC; 9 km ENE Mt Tozer, ANIC; 3 km NE Mt Webb, ANIC; Mutchilba, MV; 8 km S of Putty, ANIC; Renilworth State Forest, UQIC; 5 km W by N Rounded Hill, ANIC; 40 mile Scrub, ANIC; Shiptons Flat, ANIC; South Johnstone, QDPIM; 15 km WNW South Johnstone, QDPIM; Stewart Range, BELG; Strathmore Stn., QDPIM; Toowoomba, ANIC; Townsville, CW, FIELD, MV, QDPIM; 9.6 km SSE Yeppoon, ANIC.

New South Wales

2.4 km E Freshwater River, AM; Kyogle, AM; Valery, ANIC.

Australian Capital Territory

Black Mountain, ANIC.

Western Australia

4 km SSW Cape Bertholet, ANIC; Derby, WAM; Fitzroy Crossing, ANIC; 161 km E Kununurra, ANIC; Mitchell Plateau, ANIC; Wyndham, UQIC.

Papua New Guinea

1.6 km S Morehead, ANIC; Rouku, Western District, ANIC.

Noumea

Noumea, MNHN.

Remarks

Very distinct from other Australasian *Helochares*, by its size, shiny black colour and virtual lack of elytral stria.

Subgenus ***Hydrobaticus*** W. Macleay, 1871

Helochares (Hydrobaticus) anchoralis Sharp

Helochares anchoralis Sharp, 1890

Helochares crenatus expansus Knisch, 1921, 1924; d'Orchymont 1943
Helochares (Hydrobaticus) anchoralis expansus Knisch, 1921; d'Orchymont 1943

Description (number examined 7)

As for *H. tristis* except as follows. Length 5.5–6.2 mm. Upper surface shiny, reddish brown with scattered, ill-defined darker areas near border of head and Y suture outlined in black. Head uniformly covered in small-medium sized moderately dense punctures; pronotal punctures of uniform size, small for genus, separated from each other by their own diameter or a little less, a few larger setiferous setae in one line towards front on each side; serial punctures of elytra confluent, small, those at base about same size as those on pronotum, somewhat larger towards apex and laterally; interstrial punctures numerous, moderately dense, smaller than those in stria; area between elytron edge and most lateral striae densely covered in large punctures, the more lateral ones as large or larger than those in adjacent striae. Elytron flanged. Striae form deep grooves laterally and apically but interstrial areas flat. Aedeagus as in Figs 11 and 12.

Distribution

Papua New Guinea

Finisterre Mts, Budemu, ca 1220m, BMNH; Gusap Markham Vale, 145 km W of Lae, BMNH; Lae-Bulolo Road, BMNH; 11 km Lae-Bulolo Road, BMNH; Port Moresby, BMNH.

Remarks

I have not seen the types of either *H. anchoralis* Sharp, or *H. c. expansus* Knisch, and rely on d'Orchymont (1943) for my identification of this species. The series of specimens in the BMNH agree with Sharp and d'Orchymont's descriptions, and with the aedeagus illustrated by d'Orchymont. Among Australasian *Hydrobaticus* with uniform punctation, the species is distinctive by being large and relatively flat with broad elytral flanges and the punctures on the head smaller than the size of the eye facets. Outside New Guinea the species is widespread in South East Asia from Ceylon (type locality) to the Philippines. The type locality of *H. c. expansus* Knisch is given only as New Guinea.

Helochares (Hydrobaticus) anthonyae sp. nov.

Description (number examined 76)

As for *H. tristis* except as follows. Length 4.5–5.8 mm. Yellow-brown. Front and rear of head, Y suture on head, portions of pronotum, serial punctures on elytra and often a quite extensive area on disc of elytra darker. Punctures on head moderate in size and density, somewhat smaller towards front in middle; punctures on pronotum of uniform size, moderately sized, separated from each other by their own diameter or slightly less; strial punctures well impressed, not confluent, not forming grooves, at least twice size of those on pronotum, becoming progressively smaller in apical quarter of elytron; interstrial punctures very small, much smaller than strial punctures except towards apex where the serial punctures are much reduced in size. Sides of pronotum and elytra with fine reticulation giving mat finish. Edges of elytra not or only very weakly flanged.

Types

Holotype male: 'New Guinea: Morobe Dist., c 7 ml [11 km] Lae-Bulolo Rd. 30.xii.1964', 'Stn No. 120', 'M.E. Bacchus, BM 1965–120', in BM(NH).
Paratypes: 9 in BM(NH); 2 in SAMA; 2 in CW; all with same data as holotype

Distribution

Northern Territory

Nourlangie Creek, ANIC.

Papua New Guinea

Lae, BMNH; 7 mls [11 km] Lae-Bulolo Road, BMNH; 90 mls [145 km] W. of Lae; Mt Lamington, BMNH; Okapa, E. Highlands District, BMNH.

Remarks

Apart from the distinctive aedeagus (Fig. 1), separated from other *Helochares*, particularly *H. loweryae*, *H. dalhuntyi* and *H. thurmerae*, by characters given in key. A New Guinean species known from only one Australian specimen from the Northern Territory

Helochares (Hydrobaticus) clypeatus (Blackburn)

Hydrobaticus clypeatus Blackburn, 1891
Helochares (Hydrobaticus) clypeatus (Blackburn, 1890); Knisch 1924; d'Orchymont 1943

Description (number examined 377)

As for *H. tristis* except as follows. Length 5.1–7.2 mm. Some ill-defined dark patches on elytra.

Punctures on front of head fine, with a few much larger ones (Fig. 17); punctures on rear of head, pronotum and elytra of two sizes, the smaller similar to those on front of head, the larger much larger, in approximately equal numbers except on elytra where they are smaller and more numerous; large punctures on pronotum often separated by less than their diameter (Fig. 19); serial punctures a little larger, often confluent and forming shallow grooves. Interstrial areas virtually flat apically. Aedeagus as in Fig. 2.

Types
Holotype female: 'T 3434NT', 'Hydrobaticus clypeatus, Blackb.' in BM(NH).

Distribution

Northern Territory
1 km NE of Cahills Crossing, East Alligator River, ANIC; Berry Springs, ANIC; Bessie Spring, ANIC; Coastal Plains Research Station, CSIRO, Darwin, ANIC; Cooper Creek, ANIC; 16 km E of Daly River, SAMA; Howard Springs, ANIC; 10 km N Jabiru, QDPIM; Kakadu NP, NTM; Kapalga, QM; Koongarra, ANIC; Manton Reservoir, NTM; 19 km NE by E Mt Cahill, ANIC; 2 km N of Mudginbarry HS, ANIC; Nourlangie Creek, ANIC; Oenpelli, ANIC; Simpson Gap, ANIC.

Queensland
Atherton, ANIC; Ayr, ANIC; 8 km N Bloomfield River, ANIC; Boar Pkt Road, ANIC; Brisbane, CW, UQIC; Brookfield, QM; Caloundra, CW; Cape Tribulation, CW; Cairns, ANIC, CW, SAMA; Cape Flattery Road, QDPIM; Cardstone, ANIC; Cardwell, ANIC; Carungra Creek, QM; Cooloola, QM; Cow Bay, QDPIM; Emerald, QDPIM; Flinders Island, SAMA; Fraser Island, ANIC; Home Hill, CW; Gayndah, UQIC; Groomeri, UQIC; Hann River N of Laura, QDPIM; Hann River, 73 km NW Laura, ANIC; Helenvale, ANIC; Hope Vale Mission, ANIC; Innisfail, CW; Kuranda, ANIC, SAMA; Lam. Nat. Pk, UQIC; 75 km NW Laura, QDPIM; Mareeba, QDPIM; McIlwraith ANIC, QDPIM; 16 km S Miriam Vale, UQIC; Mission Beach, UQIC; Mossman, ANIC; Mourilyan, ANIC; 3 km NE Mt Webb, ANIC; North Pine River, UQIC; Nth Stradbroke Island, UQIC; 11 km WSW Petford, QDPIM; Petrie, UQIC; 15 km NW of South Johnstone, QDPIM; Tinaroo Dam, QDPIM; Tolga, QDPIM; 7 km N Tolga, QDPIM; Townsville, ANIC; Upper Mulgrave River, UQIC; Walkamin, QDPIM; 40 km S of Weipa, QDPIM; 80 km N Weipa, NMV; Woodford, UQIC.

New South Wales
Coffs Harbour, UQIC; Congo, ANIC; Kyogle, FIELD; Lansdowne SF, ANIC; 8 km W of Port Macquarie, ANIC; 18 km W of Uki, ANIC; Valery, ANIC; Windsor, ANIC; Wootton, ANIC.

Western Australia
Carson Escarpment, ANIC.

Remarks
A distinctive species best recognised by the form of punctation on the upper surface in which the large and small punctures are very different in size (Fig. 19). This character is difficult to describe in a key but once recognised is readily used. The sparsity of large punctures on the front portion of the head (Fig. 17) is usually a reliable character but does not separate all *H. clypeatus* from all *H. tristis*.

FIGURE 17. Head of *H. clypeatus*.

Helochares (Hydrobaticus) dalhuntyi sp. nov.

Description (number examined 30)
As for *H. tristis* except as follows. Length 4.2–5.5 mm. Oval. Dark testaceous; patches of lighter colour on upper surface particularly laterally and at bases of elytra, palpi and tarsi lighter. Front margin of head deeply and widely concave. Punctures on head and pronotum uniformly sized, small for *Helochares*, separated by less than own diameter in most cases, somewhat larger laterally; punctures in elytral interstriae numerous (Fig. 21), much smaller than those on pronotum, a row of larger seta-bearing punctures inwards from striae

six; punctures in stria variably confluent, deeply impressed, much larger than those on pronotum. Aedeagus as in Fig. 8.

Types
Holotype male: right hand specimen of two mounted on card, 'Dalhunty River, Qld, 1/10/83, C. Watts', in SAMA.
Paratypes: 1, mounted upside down on same card as holotype in SAMA; 3, mounted on same card, same data as holotype, in CW; 1, 'Captain Billy Creek, CW', in CW.

Distribution

Queensland
Captain Billy Creek, CW; Dalhunty River, CW; East Claudie River, UQIC; Iron Range, ANIC, AM, UQIC; 2 km NNE Mt Tozer, ANIC; 3 km ENE Mt Tozer, ANIC; 6 km ENE Mt Tozer, ANIC; 8 km E by N of Mt Tozer, ANIC; 9 km ENE Mt Tozer, ANIC; 11 km ENE Mt Tozer, ANIC.

Northern Territory
Darwin, CW; Roderick Creek, Gregory NP, NTM.

Remarks
Helochares dalhuntyi is difficult to separate from *H. loweryae* except by the aedeagus. The punctation of the upper surface is stronger than in all but a few *H. loweryae*, but I have been unable to reliably quantify this difference.

Helochares (Hydrobaticus) loweryae sp. nov.

Description (number examined 25)
As for *H. tristis* except as follows. Length 4.4–5.5mm. Oval. Light testaceous; patches of darker colour on dorsal surface. Front margin of head deeply and widely concave. Punctures on head and pronotum uniform in size, small for genus, separated by about own diameter or less in most cases, only slightly larger laterally; punctures in elytral interstriae numerous, much smaller than those on pronotum, a row of large setose punctures inwards from stria 6; interstriae sub-obsolete apically, on shoulders and between lateral-most striae; punctures in stria separate, deeply impressed, much larger than those on pronotum, larger towards sides than on disc; lateral punctures on elytra small but well impressed, larger than those in adjacent interstriae. Aedeagus as in Fig. 7.

Types
Holotype male: 'Mt Lamington, N.E. Papua, 1300 to 1500 feet, C. J. McNamara', in SAMA.
Paratypes: 1, 'New Guinea: Morobe Dist., Lae-Bulolo Rd, 30.xii.1964'. 'Stn. No. 131', in BM(NH). 1, 'New Guinea: Morobe Dist., Gusap, Marthany Valley, c. W. of Lae. 22–30.i. 1965'. 'M.E. Bacchus, BM 1965–120'. 'Stn. No. 166', in BM(NH). 1, 'New Guinea: Morobe Dist., c. 7 ml Lae-Bulolo Rd. 30.xii.1964'. 'Stn. No. 120'. 'M.E. Bacchus, BM 1965–120', in BM(NH). 1, 'New Guinea: Morobe Dist. Herzog Mts., Vagau. c. 4,000 ft 4–17.i.1965'. 'M. E. Bacchus, BM 1965–120', in CW.

Distribution

Northern Territory
Darwin River Reservoir, NTM; Holmes Jungle, ANIC; Howard Springs, CW, NTM.

Papua New Guinea
Bulolo, BM(NH); Kokoda, BM(NH); Morobe District, BM(NH); Mt Lamington, SAMA; Lae-Bulolo Road, BM(NH); 5 km Lae-Bulolo, BM(NH); 11 km Lae-Bulolo, BM(NH); 145 km W. of Lae, BM(NH); Vagav, Herzog Mts, BM(NH).

Remarks
The specimens from the Northern Territory differ from typical specimens by having somewhat stronger interstrial punctures and having the lateral 'wings' of the aedeagus (Fig. 8) more separate from the centre piece than in New Guinea specimens. Close to *H. dalhuntyi* and difficult to separate from it other than by the shape of the aedeagus. Most specimens can be separated by the different strength of the dorsal punctation but this is difficult to use unless specimens of both species are available. The Northern Territory specimens appear intermediate in this regard.

Helochares (Hydrobaticus) luridus (W. J. Macleay)

Hydrobaticus luridus W. J. MacLeay, 1871

Description (number examined 144)
As for *H. tristis* except as follows. Length 3.5–5.4 mm. Larger punctures usually smaller than those of *H. tristis*, serial punctures usually confluent over most of elytra forming quite strong grooves, interstrial areas towards apex of elytra and laterally weakly ridged, ridging effect

accentuated by relatively deeply indented striae; lateral punctures around elytron get progressively smaller towards apex where they are usually less than one quarter diameter of those towards front corner of elytron (Fig. 23). Aedeagus as in Fig. 5.

Types
Holotype, ?sex. 'Hydrobaticus luridus McL.W. Gayndah' 'K1924' with small circular red label and red Holotype label, in AM.

Distribution

Northern Territory
16°02'S, 130°23'E, NTM; 16°07'S, 130°24'S, NTM; 16°07'S, 130°25'E, NTM; Sth Alligator River, QM; Cooper Creek, ANIC, SAMA; Fergusson River, ANIC; Gregory NP, NTM; Howard Springs, ANIC; Humbert River, NTM; Humpty Doo, QDPIM; Junction of Arnhem Hwy. and Oenpelli Road, NTM; Oenpelli Road, NTM; Kakadu, NTM; Katherine, SAMA; Larrimah, QM; 13 km S Lawn Hill Stn., QM; McArthur River, ANIC; 19 km E by N of Mt Cahill, ANIC; 19 km WSW Mt Cahill, ANIC; 19 km NE by E Mt Cahill, ANIC; 12 km NNW Mt Cahill, SAMA; 2 km N Mudginbarry HS, ANIC; Nabarlek Dam, ANIC; 18 km E by N of Oenpelli, ANIC; Renner Springs, CW; Tennant's Creek, NMV; 12 km NNE Victoria River Downs, ANIC.

Queensland
Annan River, ANIC; Ayr, ANIC; Barron Falls, ANIC; Brookfield, QM; 29 km S Burketown, QM; Burnett River N of Eidswald, ANIC; Cardstone, ANIC; Cairns, ANIC, Charleville, ANIC; 25 km N Coen, CW; Cooktown, ANIC, CW; 40 km N Cooktown, ANIC; Cunnamulla, AM, SAMA; Daintree, ANIC; Dalby, SAMA; Dipperu, QM; Ellery Creek, NMV; Gayndah, SAMA; 12 km SE Gympie, NMV; Innisfail, QM; Iron Range, UQIC; Laura, CW; 73 km NW by W Laura, ANIC; 75 km NW Laura, QDPIM; Little Laura River, QM; Mary Creek, ANIC; McIlwraith Range, CW; 34 km S Mirian Vale, ANIC; Mossman, ANIC, SAMA; Mt Garnet, CW; 3 km ENE Mt Tozer, ANIC; 14.5 km W Paluma, ANIC; 11 km NSW Petford, QDPIM; Rockhampton, SAMA; Rocklea, QM; 15 km NNW South Johnstone, QDPIM; Station Creek, ANIC; Strathmore Station, QM; Tolga, QM; 7 km NE Tolga, QDPIM; Townsville, AM.

New South Wales
Valery, ANIC.

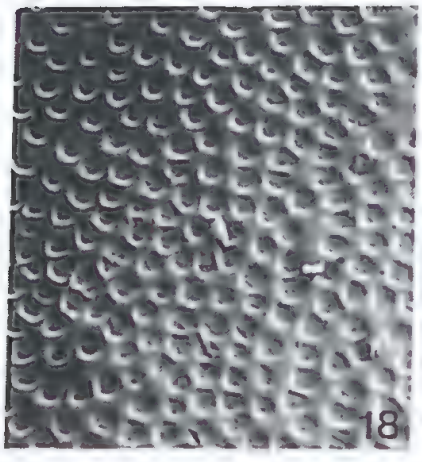
Western Australia
Carson Escarpment, ANIC; Kalumburu, ANIC; Mitchell Plateau, ANIC; 5 km SE Pago Mission, FIELD.

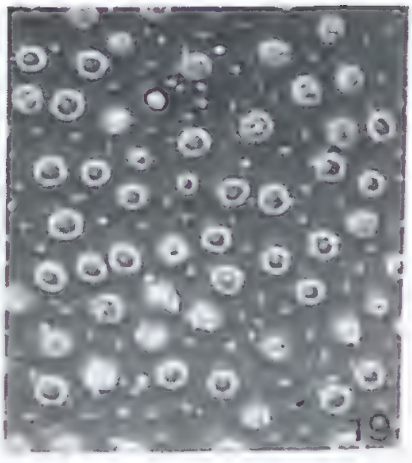
Remarks
The distinctive aedeagus (Fig. 5) is the only reliable character separating *H. luridus* from *H. tristis*. Over most of its range *H. tristis* has no trace of elytral ridging or indented stria, which are almost always a feature of *H. luridus*. Unfortunately it is in the area of distributional overlap in southern Queensland that the two species are hardest to separate since most *H. tristis* from this area have quite well marked apical ridging and grooving on elytra. The character used in the key—small lateral punctures at apex of elytron in *H. luridus*—appears to work, but is often difficult to see clearly and, at best, is a subjective character.

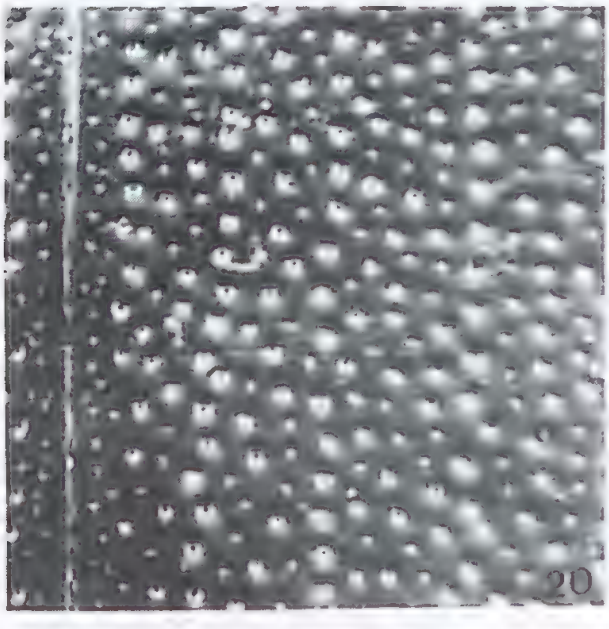
H. luridus was synonymised with *H. tristis* by Knisch (1924), Zaitzev (1908) and by d'Orchymont (1943). These species are very similar, but readily differentiated by the aedeagus. The holotypes of both species are from Gayndah in southern Queensland where both species are known to occur. Both types are fragile and I think females. I have not attempted to dissect them. The type of *H. luridus* is paler and is almost identical to a male specimen of the northern species from Gayndah in SAMA. The type of *H. tristis* is darker and agrees in diagnostic features with the southern form.

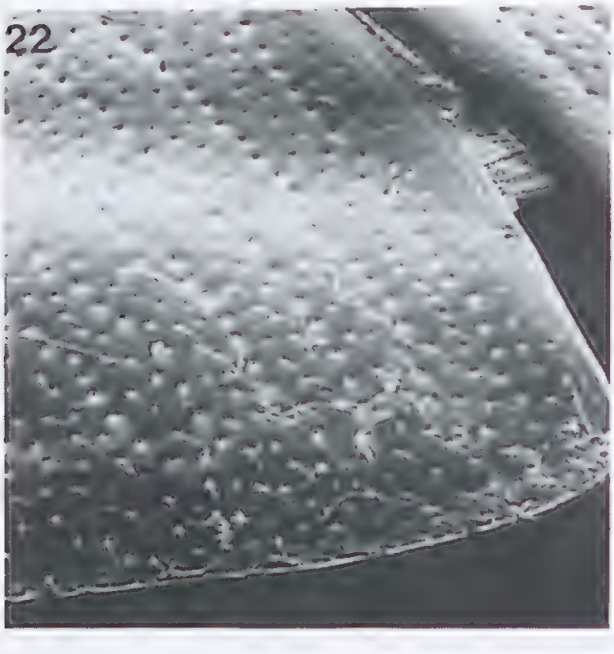
Helochares (Hydrobaticus) marreensis sp. nov.

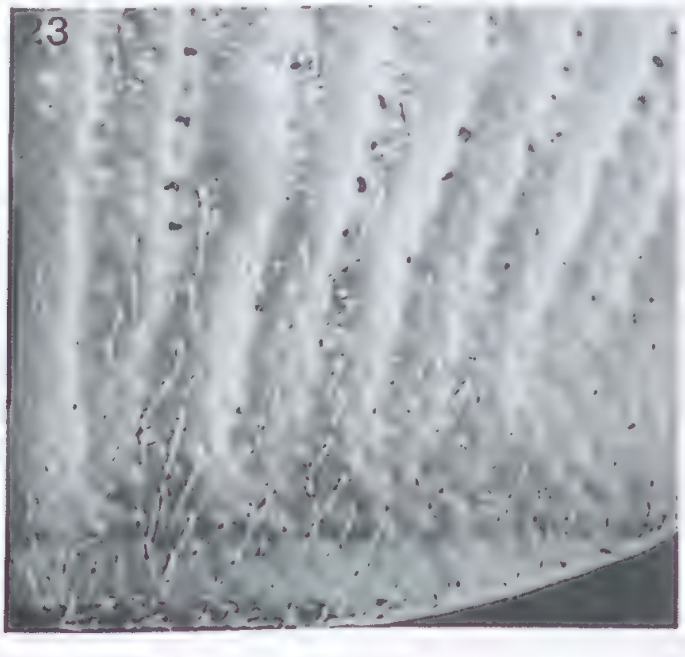
Description (number examined 147)
As for *H. tristis* except as follows. Length 4.0–5.4 mm. Elongate, reddish-brown including clypeus. Darker markings on head and pronotum vague and often absent, elytra rather evenly speckled brown and reddish-brown or, in some examples, with linear dark lines. Punctures on head numerous, dense, large at base, grading to quite small in front; punctures on pronotum even, moderately large, most separated by less than their diameter, particularly towards sides; punctures in interstriae numerous, strong, those at base near suture about same size as those on pronotum, becoming smaller towards rear and sides of elytra; strial punctures almost confluent, weakly impressed, same size or slightly smaller than those on pronotum and base of elytron. I have been unable to distinguish the aedeagus from that of *H. tatei* (Fig. 6).











FIGURES 18–23. **18** Pronotal disc of *H. percyi*; **19** Pronotal disc of *H.clypeatus*; **20** Portion of elytral disc of *H. tristis*; **21** Portion of elytral disc of *H. dalhuntyi;* **22** Tip of elytron of *H. tristis;* **23** Tip of elytron of *H. luridus*.

Types
Holotype male: '12°23'S 132°56'E, 7 km NW by N of Cahills Crossing, East Alligator River, NT, 27.v.73, E.G. Matthews', in SAMA.
Paratypes: 3, '12°26'S 132°56'E, Cahills Crossing, NT, East Alligator River, 29.v.73, at light, E.G. Matthews', in SAMA; 2, '12°48'S 132°42'E, Nourlangie Creek, NT, 8 km N of Mt Cahill, 21.v.73, at light, E.G. Matthews', in SAMA; 2, '12°25'S 132°58'E, 1 km N of Cahills Crossing, NT, East Alligator River, 7.vi.73, Upton and Feeham', in ANIC; 2, '12°46'S 132°39'E, 12 km NNW of Mt Cahill, NT, 15.vi.73, Upton and Feeham', in ANIC; 1, '12°23'S 132°56'E, 7 km NW by N of Mt Cahills Crossing, East Alligator River, NT, 9.vi.73, Upton and Feeham', in ANIC; 3, 'Forbes, NSW, 15.iii.63, E.W.', in CW.

Distribution

Northern Territory
16°02'S, 130°23'E, NTM; Adelaide River, ANIC; Baroalba Creek Springs, ANIC; 13 km SW Borroloola, ANIC; 30 km NE by E Borroloola, ANIC; 1 km N Cahills Crossing, SAMA, ANIC; 5 km NNW Cahills Crossing, ANIC; 7 km NW by N Cahills Crossing, SAMA, ANIC; Cahills Crossing, SAMA, ANIC; Cooper Creek, SAMA, ANIC; Daly River, ANIC, NMV; Fogg Dam, NTM; Howard Springs, CW; 10 km N Jabiru, QDPIM; Junction of Arnhem Hwy and Oenpelli, NTM; Katherine, ANIC; Koongarra, ANIC; McArthur River, ANIC; 13 km N Mt Cahill, SAMA; 9 km N by E Mudginbarry HS, ANIC; 6 km SW by S Oenpelli, ANIC, SAMA; Renner Springs, SAMA; Tindal, ANIC; U.D.P. Falls, NTM; 30 km N Wauchope, ANIC.

Queensland
Bunya Mountains, ANIC; 16 km S Miriam Vale, UQIC; Crystal Creek, ANIC; Cunnamulla, QM, SAMA; Dalby, QM, SAMA; 68 km East Roma, QM; 96 km E Hughenden, UQIC; Julia Creek, CW; Marina Plains, QDPIM; 16 km S Miriam Vale, UQIC; Musgrave HS, ANIC; Nocundra, ANIC; Normanton, SAMA; Silver Plains, UQIC.

New South Wales
Canowindra, VM; Forbes, CW; Gilgandra, CW; Moree, SAMA; Mt Kaputar, ANIC.

Victoria
Lake Hattah, ANIC, QDPIM; Wyperfield National Park, ANIC.

Western Australia
3 km S Coulomb Pt, ANIC; Fitzroy Crossing, ANIC; Kununurra, ANIC; Lennard River Xing, WAM.

South Australia
Marree, SAMA.

Remarks
An elongate, parallel sided species with strong interstrial punctures which, over most of elytra, are as large as the strial punctures. Uniquely, among Australasian species at least, the aedeagi of *H. marreensis* and *H. tatei* are so similar that I have not been able to distinguish them. The two species are readily separated by the punctation of the upper surface which is much stronger in *H. marreensis*, and the presence of more than one row of punctures in interstriae 7–8 and 9–10 in *H. marreensis* compared to a single row in *H. tatei*.

Helochares (Hydrobaticus) percyi sp. nov.

Description (number examined 101)
As for *H. tristis* except as follows. Length 4.8–6.0 mm. Oval, rather flattened. Yellow-brown. Clypeus darker, extreme sides of pronotum and elytra lighter. Punctures on head and pronotum large, dense, of uniform size (Fig. 18), those at sides of pronotum and head slightly larger and closer together; interstrial punctures small to medium, dense, uniform in size; serial punctures nearly confluent, deep, larger than punctures on pronotum. Interstrial areas weakly ridged near apex and laterally. Aedeagus as in Fig. 10.

Types
Holotype male: 'Boar Pkt.Rd., N.Q. 2 12.70 J.G. Brooks', in ANIC.
Paratypes: 1, 'Boar Pkt.Rd., N.Q. 1/70 J.B.' 'J.B.B. 27' J.G. Brooks. Bequest, 1976, in ANIC; 1, 'Boar Pocket Road, ca 8 km N of Gillies Hwy, Qld 21.ii.70, at light, J. G. Brooks', ANIC; 2, 'McIlwraith Rng., Weather Stn., N. Qld, 23/7/82, C. Watts', in SAMA.

Distribution

Northern Territory
Adelaide River, ANIC.

Queensland
Atherton, QDPIM; Brisbane, UQIC; Cardstone, ANIC; Cairns, CW; Eidsvold, ANIC; Emu Vale, UQIC; 8 km N of Gillies Highway, ANIC; 12 km

SE Gympie, NMV; 37 km SSE Ingham, ANIC; Iron Range, UQIC; Jimboomba, ANIC; Julatten, UQIC; Kenilworth State Forest, AM; Koombaloomba, BM(NH); Kuranda, ANIC; 18 km W Mareeba, QDPIM; McIlwraith Range, Weather Stn., CW; 117 km NW by W Laura, ANIC; Mossman, ANIC; Mt Finnigan, ANIC; Mt Spec, ANIC; Oxley Creek, QM; Palmerston National Park, ANIC, UQIC; 24 km W of Paluma, ANIC; Nth Pine River, QM; Sth Pine River, QM; 32 km S of Ravenshoe, ANIC; 15 km WNW South Johnstone, ANIC; Tolga, QDPIM; Wilson's Peak, UQIC.

New South Wales

Armadale, CW; Blue Mountains, ANIC; Canterbury, SAMA; Coffs Harbour, UQIC; 12 km N Eccleston, NMV; 9 km SW Gloucester, NMV; Hastings River, ANIC; Nepean River, ANIC; Salisbury, UQIC; Taree, ANIC; 18 km W of Uki, ANIC; Wahroonga, ANIC.

Australian Capital Territory

Black Mountain, ANIC.

Western Australia

Carson Escarpment, ANIC.

Remarks

A broad flat species with large close-packed punctures on pronotum (Fig. 18). Many specimens have broad, weakly-flanged elytra often distinctly truncated at apex. A wet area species common in north Queensland but present as far south as the Blue Mountains and the Australian Capital Territory.

Helochares (Hydrobaticus) tatei (Blackburn)

Hydrobaticus tatei Blackburn, 1896
Helochares (Hydrobaticus) tatei (Blackburn, 1896), Knisch 1924; d'Orchymont 1943

Description (number examined 483)

As for *H. tristis* except as follows. Length 3.4–4.8 mm. Elongate oval, elytra variegated light and dark-brown. Head and pronotum quite densely covered with large well impressed punctures, a little larger laterally, most punctures on pronotum separated by less than half their widths; interstrial punctures on elytra fine, numerous, those in interstriae 7-8 and 9-10 (ignoring short innermost stria) arranged in single loose row; strial punctures large, much larger than punctures on pronotum, mostly confluent, deeply impressed, forming strial grooves, interstrial area flat. Aedeagus as in Fig. 6.

Types

Syntypes: One, in NMV mounted on a card labelled 'Reedy Ck.' and bearing labels, 'Cent. Aust. Coll. Horn. Exp. Pres. 7.94', 'Hydrobaticus tatei, Blackb', in addition it has a modern red label with 'Type' printed on it; two specimens on the same card on which is written 'T Co-type 5484 Palm Ck.' in Blackburn's hand and labelled 'Hydrobaticus tatei Blackb.' in SAMA; One specimen labelled '5484 Palm Ck, Hydrobaticus tatei Blackb. co-type' in SAMA; ten specimens in NMV mounted two to a card on each of which is written 'Palm Ck.' in Blackburn's hand; two of these are labelled 'Cent. Aust. Coll. Horn. Exp. Pres. 7.97' and 'Hydrobaticus tatei Blackb. det. by Blackb.', one pair bears only the locality label, another only the species label and the last pair has no label. All are clearly from the same series as the other syntypes.

Since the use of 'T' to denote his Holotypes was a normal practice of Blackburn's. I consider the specimen in SAMA so labelled to be the specimen intended by Blackburn as the Holotype. I nominate it as the lectotype and all the other specimens mentioned above as paralectotypes.

Distribution

Northern Territory

Adelaide River, BELG, ANIC; Berry Springs, ANIC; 33 km SW Borroloola, ANIC; 7 km NW by N of Cahills Crossing, East Alligator River, ANIC; Cahills Crossing, East Alligator River, ANIC; Coastal Plains Station, ANIC; Cooper Creek, ANIC; Darwin, BELG, CW; Fogg Dam, ANIC, NTM; Howard Springs, CW, NTM; Huckitta, ANIC, SAMA; Humpty Doo, ANIC; Jim Jim Creek, ANIC, SAMA; Junction Arnhem Hwy and Oenpelli Road, NTM; Kakadu N P, NTM; Katherine, ANIC; Koongarra, ANIC; Magela Creek, ANIC; Manton Reservoir, NTM; McArthur River, ANIC; 16 km E by N of Mt Cahill, ANIC; Mt Gilruth, QM; 9 km N by E of Mudginbarry HS, ANIC, SAMA; Nourlangie Creek, ANIC; 18 km E by N. of Oenpelli, ANIC; 4,8 km S Renner Springs, SAMA; South Alligator R., ANIC, QM; 6.5 km W Timber Creek, SAMA.

Queensland

Archer River, ANIC; Archer Bend, CW; Boggy Creek, ANIC; 25 km N, Coen, CW; NW by W. Laura, East Claudie River, UQIC; 60 km S, Coen, CW; Colosseum Creek, 16 km S Miriam Vale,

UQIC; Cooktown, ANIC; Dalhunty River, CW; Hann River, 73 km S of Coen N. CW; Hann River, 110 km S of Coen N. NMV; Iron Range, UQIC; Mornington Island Mission, SAMA; 3 km ENE Mt Tozer, ANIC; Musgrave, ANIC; Normanton, SAMA; Rockhampton, ANIC.

New South Wales

32 km SSW Bourke, SAMA; Whitton, SAMA.

Western Australia

21°31.55 S., 119°06.57 E, WAM; Beverley Springs, WAM; Behn River, SAMA; 172 km SSE of Carnarvon, ANIC; Carson escarpment, ANIC; Charnely River, 40 km N, Beverley Springs, WAM; Dampier Island, FIELD; Drysdale River, ANIC; Milstream, ANIC, WAM; Mitchell Plateau, ANIC, FIELD; 8 km NNE Mt Broome, WAM; Murchinson River, ANIC; 5 km S, Pago Mission, FIELD; Woodstock Station, WAM.

South Australia

Arkaroola Creek, SAMA; Brachina Creek, SAMA; Mt Chambers Gorge, CW, SAMA; 16 km E Curdimurka, SAMA; Eringunda Valley, SAMA; Salt Creek, SAMA; Wilpena Pound, SAMA.

New Caledonia

Grotte de Ninain Rev Poya, SAMA.

Remarks

Resembles *H. (H.) marreensis* in its narrow shape and similar male genitalia. *H. tatei* can be separated from this species by having interstrial punctures much weaker than those in adjacent striae and having only one row of punctures in interstriae 7–8 and 9–10. As far as I know this is the first record of this species from New Caledonia.

Helochares (Hydrobaticus) tenuistriatus Régimbart

Helochares tenuistriatus Régimbart, 1908
Helochares (Hydrobaticus) tenuistriatus Régimbart, 1908; Knisch 1924; d'Orchymont 1943.

Description (number examined 9)

As for *H. tristis* except as follows. Length 5.2–6.5 mm. Oval. Distinctly reddish, upper surface with darker markings. Front margin of head broadly concave. Punctures on head and pronotum of two sizes, smaller ¼–½ diameter of larger which are separated by about their own diameter, slightly larger laterally; punctures on elytron rather similar in size, with strial punctures relatively small and weak and not much larger than larger interstrial punctures, which in turn are often not much larger than smaller interstrial punctures; interstrial punctures not confluent, not forming grooves or ridges. Aedeagus as in Fig. 4.

Types

Syntypes, in MNHN. Type locality, Mongers Lake, North Subiaco, Perth, Western Australia; 1, from same series in WAM. Lectotype not designated.

Distribution

Western Australia

Busselton, CW; Bunbury, AM; Camel Lake, WAM; King George Sound, AM; Mogumber, WAM; North Lake, Fremantle, FIELD; Ravensthorpe, ANIC; Swan River, ANIC; SAMA; Swan View, ANIC.

Remarks

Separated from *H. tristis* by the distinctive reddish hue and the comparative uniformity of punctures on the elytra. The aedeagus is distinctive. In the relatively few specimens I have seen there is no hint of elytral grooves or ridges as in some *H. tristis* and virtually all *H. luridus*. Although I saw the types many years ago they are temporarily unavailable and I have relied on my notes and descriptions by Régimbart and d'Orchymont and the illustration of the aedeagus given by d'Orchymont to identify this species. I have not designated a lectotype due to the unavailability of the Paris specimens.

Helochares (Hydrobaticus) thurmerae sp. nov.

Description (number examined 15)

As for *H. tristis* except as follows. Length 3.8–5.0 mm. Reddish-yellow; rear of head, front of pronotum, serial punctures and other areas of upper surface darker. Punctures on head subequal, small for subgenus, separated by half to one times their diameters, somewhat smaller towards front; punctures on pronotum a little denser and stronger than on head; strial punctures on elytra well impressed, much larger than those on pronotum, separate but close to each other, those on disc somewhat smaller than elsewhere including apical declivity; interstrial punctures of uniform size, much smaller than those on pronotum, moderately

impressed, those of lateral fringe larger. Elytra weakly flanged. Aedeagus as in Fig. 9.
Male: Protarsi and claws a little stouter than in female.

Types
Holotype male: 'New Guinea: Morobe Dist., Gusap, Markham, Valley c. 90 ml W. of Lae, 1,000 ft 27–30.i.1965'. 'M.E. Bacchus, BM, 1965–120'. 'Stn. No. 166', in BM(NH).
Paratypes: 4, in BM(NH); 1, in CW; 1, in SAMA, same data as Holotype.

Distribution

Papua New Guinea
Gusap Markham Valley, 145 km W of Lae, BM(NH); Lae, BMNH; 11 km Lae-Bulolo Rd., BM(NH).

Remarks
Known only from a relatively small area of New Guinea. Apart from the aedeagus, *H. thurmerae* can be separated from the rather similar *H. loweryae* and *H. dalhuntyi* by the strial punctures being larger and fewer than in those species.

Helochares (Hydrobaticus) tristis Macleay

Helochares tristis Macleay, 1871
Hydrobaticus australis Blackburn, 1888; syn. nov.

Description (number examined 250)
Length 3.8–6.1 mm. Oval, widest behind centre of elytra. Yellow-brown. Clypeus, back of head, markings in central panel of pronotum and much of underside darker. Front margin of head shallowly and widely concave. Head and pronotum densely covered with punctures of two sizes, in approximately equal numbers, larger much larger than smaller; punctures denser, larger and more numerous laterally. Elytra similarly punctured (Fig. 20), with, in addition, ten more or less distinct lines of serial punctures; lateral band of punctures on elytron continues strongly to apex. Serial punctures same size or larger than larger interstrial punctures. Pronotum and elytra weakly flanged. Maxillary palpi elongate, first and second segments subequal in length, apical somewhat shorter. Femur with rugose portion covered with short setae, covering all but small portion of apex of femora. Underside rugose punctate. Sternites with covering of short setae; apex of apical sternite broadly notched, notch with row of stout setae along margin practically filling up area of notch.
Male: Maxillary palpi, tarsi and tarsal claws slightly stouter than in female. Aedeagus as in Fig. 3.

Types
H. tristis: Holotype, ?sex 'Hydrobaticus tristis Mcl. W. Gayndah' 'K19621' with small circular red label and red Holotype label, in AM.
H. australis: Syntypes: two male specimens mounted on same card, under the left hand specimen is the number 410 & 'T'. The pin has the following labels; BM(NH) Type label, 'Blackburn coll. 1910–236', 'Hydrobaticus australis Blackb.', in Blackburn's hand, in BM(NH); one labelled '410, Port Lincoln Blackburn, Hydrobaticus australis Blackb., co-type' in SAMA; two mounted on same card labelled '410, Port Lincoln Blackburn, Australis Blackb.' in SAMA (there is an empty card labelled '410' on same pin). I nominate the left hand specimen in the BM(NH) below which is written '410 T' as the lectotype, and the remaining syntypes as paralectotypes. Synonymy is based on examination of types.

Distribution

Northern Territory
Ayers Rock, UQIC; 80 km W Mt Olga, WAM; 160 km W Mt Olga, WAM; Vaughan Springs, CW.

Queensland
Brisbane, UQIC; Brookfield, QM; Cunnamulla, QM; Dalby, QM; Goomeri, UQIC; Green Island, WAM; Jimboomba, ANIC; Malanda, CW; 16 km S Miriam Vale, UQIC; Stanthorpe, BELG, UQIC; Tambourine Mt., QM.

New South Wales
Blowering Dam, ANIC; Cooma, ANIC; 23 km NNE Coonabarabran, ANIC; 15 km S Condobolin, ANIC; Culcairn, ANIC; Deniliquin, ANIC; Forbes, CW; Forest Reefs, SAMA; Kitty's Creek, ANIC; Macleay River, ANIC; Muswellbrook, ANIC; Native Dog, ANIC; Sydney, BELG, NMV; Yanco Creek, ANIC.

Australian Capital Territory
Acton, ANIC; Canberra, ANIC; Gungahlin, ANIC; 3 km NW Tharwa, ANIC.

Victoria

Alexandra, NMV; Anakie, NMV; Avoca, NMV; 11 km NNW Ballan, ANIC; Ballarat, ANIC; Birchip, NMV, UQIC; Dandenong Range, NMV; 34 km E Echuca, ANIC; Ferntree Gully, NMV; Grampians, UQIC; Healesville, CW, NMV; Inglewood, NMV; Iona, ANIC; L. Colac, NMV; L. Punrumbeti, NMV; Lake Hattah, NMV; Latrobe River, NMV; Lilydale, SAMA; Maffra, NMV; 8 km SW Maffra, ANIC; Melbourne, NMV, UQIC; Mitta Mitta River, NMV; Mordialloc, NMV; Mornington, UQIC; Natya, NMV; Preston, NMV; Sea Lake, UQIC; Goudie, UQIC; 13 km SE Shepparton, ANIC; Stawell, CW; Suggar Buggar, NMV; Tynong, NMV; Morwell, ANIC; 4 km W Violet Town, ANIC; Wartook, NMV; Whittlesea, NMV.

Tasmania

Asbestos Range NP, ANIC; East Tamar, SAMA; Launceston, SAMA; Hobart, BELG, NMV, SAMA.

South Australia

Adelaide, CW; Blanchetown, SAMA; Chain of Ponds, CW; 13km N Ernabella, FIELD; Everard Ranges, SAMA; Flinders Ranges, CW; Gawler, SAMA; Gawler Ranges, SAMA; Mannum, CW; Mt Barker, SAMA; Murray River, NMV; Olary, ANIC; Scorpion Springs C.P., SAMA.

Western Australia

8 km S Giles, WAM; Gill's Pinnacle, WAM.

Remarks

Elytra are usually smooth (except for punctures) (Fig. 22) but in some specimens, particularly from more northern localities, the strial punctures are confluent towards apex forming grooves, and in some the interstrial areas are ridged accentuating the grooving in a way very similar to *H. luridus*. This species appears to be replaced in south-west Western Australia by *H. tenuistriatus*, a slightly larger species recognisable by its uniform reddish colour and strong interstrial punctures. *H. tristis* is sympatric with *H. luridus* in southern Queensland. The difference between these two species is discussed under *H. luridus*.

Acknowledgments

Without the support of a professional infrastructure this work would have been impossible. I thank the curators of the collections listed earlier for allowing me to examine specimens in their care; Ms D. Churches, Ms R. Cherrington and Mrs V. Wade typed the manuscript; Ms J. Thurmer drew the figures of the male genitalia; Ms J. Forrest took the SEM photographs; Mrs M. Anthony ferreted out obscure references and Dr E. Matthews much improved the manuscript. I thank them for their help in what are perhaps the less exciting aspects of scientific endeavours but nevertheless necessary ones.

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THE KAMPTOZOAN *PEDICELLINA WHITELEGGII* JOHNSTON & WALKER, 1917 AND OTHER PEDICELLINIDS IN AUSTRALIA AND NEW ZEALAND

K. WASSON

WASSON, K. 1995. The kamptozoan *Pedicellina whiteleggii* Johnston & Walker, 1917 and other pedicellinids in Australia and New Zealand. *Records of the South Australian Museum* **28**(2): 131–141.

Colonies of the kamptozoan (entoproct) *Pedicellina whiteleggii* are ubiquitous in the low intertidal and shallow subtidal zones of southern Australia and New Zealand. This species has been known under a variety of names, but can be distinguished from other pedicellinids by a suite of traits including longitudinal rows of conspicuous oblong cells on each tentacle, and a tall, narrow, particle-covered larva. *Pedicellina whiteleggii* is re-described and illustrated, and compared to all other pedicellinids reported from the waters around Australia and New Zealand. *P. whiteleggii* is a senior synonym of *P. hispida* and appears to be very similar to a number of other pedicellinids reported from these waters. However, *P. whiteleggii* is clearly distinct from three other species (*P. cernua*, *P. compacta* and *P. pyriformis*) known from Australia and New Zealand. The distribution of all these pedicellinids is discussed, and the importance of larval traits in kamptozoan taxonomy is emphasised.

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Manuscript received, 30 May 1995.

Members of the phylum Kamptozoa (Entoprocta) have rarely been studied in Australia and New Zealand. There are about twenty published reports on the kamptozoan fauna of these regions, and only a few of these have involved detailed taxonomic investigations (Hastings 1932, Johnston & Angel 1940, Ryland 1965).

Examination of museum collections revealed that only one pedicellinid species is common in the shallow waters of Australia and New Zealand. This species, *Pedicellina whiteleggii* Johnston & Walker, 1917, accounts for most of the museum specimens of *Pedicellina* from these waters. Published records and museum labels refer to these specimens under various names, but a suite of distinctive traits unites them. The ubiquitous nature of this species on these southern seashores was reinforced by field collections which indicated that colonies were present on many low intertidal and shallow subtidal substrata at all sites surveyed.

The purpose of this report is to unify these various specimens under one name, *Pedicellina whiteleggii*, and to justify this unification by describing the configuration of traits which characterises members of this species. This re-description of *P. whiteleggii* is followed by a brief review of all other pedicellinids known from Australia and New Zealand.

Materials And Methods

I examined all pedicellinid kamptozoans from localities around Australia and New Zealand deposited in the collections of the South Australian Museum (SAM), the Australian Museum (AM), the Museum of Victoria (NMV), the Museum of Tropical Queensland (MTQ), the Otago Museum (OM), the Portobello Marine Laboratory of the University of Otago (PML), and the British Natural History Museum (BMNH). Apparently no other museums contain collections of pedicellinids from Australia or New Zealand.

I collected live pedicellinids from the low intertidal or shallow subtidal zone at Fairlight, Port Jackson, New South Wales; Aldinga Reef, Gulf St. Vincent, South Australia; Pukerua Bay, North Island, New Zealand; and Aquarium Point, Otago Harbour, South Island, New Zealand. At each site, about one hour was devoted to collecting various living and non-living substrata from sheltered habitats under rocks or overhangs. These substrata were then examined under a stereomicroscope to detect pedicellinid colonies. This two step method of searching revealed that at each site pedicellinids were present on about 5–10% of the substrata collected.

Systematics

Phylum KAMPTOZOA Cori, 1929
(= Entoprocta Nitsche, 1870)

Order COLONIALES Emschermann, 1972

Sub-Order STOLONATA Emschermann, 1972

Family PEDICELLINIDAE Hincks, 1880

Genus *Pedicellina* Sars, 1835

Pedicellina whiteleggii Johnston & Walker, 1917 (Figs. 1–4).

? *Pedicellina sp.* MacGillivray, 1887: 221, no fig.

Pedicellina cernua (Pallas, 1774) *sensu* Whitelegge, 1889: 293, no fig.

Pedicellina whiteleggii Johnston & Walker, 1917: 60, fig. 14; Stach 1937: 374, no fig.

Pedicellina hirsuta Jullien, 1891 *sensu* Johnston & Angel, 1940: 227, figs. 38–42.

Pedicellina hispida (from New Zealand) Ryland, 1965: 197, fig. 5.

Gordon, 1972: 510, fig. 3.

non *Pedicellina cernua* (Pallas, 1774):57, fig. 10 in plate 4.

non *Pedicellina hirsuta* Jullien, 1891:13, no fig.

non *Pedicellina hispida* (from Europe) Ryland, 1965:200, fig. 8.

Etymology

Johnston & Walker (1917) named this species *Pedicellina whiteleggii* to honour Thomas Whitelegge, who had earlier collected colonies of the same species from the Port Jackson area. Whitelegge in 1883 became the first cataloguer of marine invertebrates at the Australian Musuem, and held that position until 1908. Whitelegge contributed greatly to the characterisation of the invertebrate fauna of the region, and was one of few Australians to report the presence of kamptozoan species on these seashores.

Type

Johnston & Walker provided two syntypes (SAM E942 and E943) of this species. I now designate SAM E942 as the lectotype; SAM E943 thereby becomes a paralectotype.

Type Locality

Johnston & Walker (1917) indicate that the types of *Pedicellina whiteleggii* were collected under stones in the intertidal zone at Port Jackson, NSW. They list both Middle Harbour and Watson's Bay as collection sites, and do not specify at which of these two localities the types were taken.

Material Examined

South Australia: Port Willunga, intertidal, 25.iii.1944, SAM L709; Outer Harbour, 0.5 m, R.G. Chittleborough, 2.v.1951, SAM L710; Point Turton Jetty, Yorke Peninsula, 3–4 m, K. Gowlett-Holmes, 2.iv.1994, SAM L711; Aldinga Reef, Gulf St. Vincent, 1–2 m, S.A. Shepherd & K. Wasson, 18.ii.1995, SAM L712; Aldinga Reef, Gulf St. Vincent, 1–2 m, S.A. Shepherd & K. Wasson, 18.ii.1995, personal collection of K. Wasson.

New South Wales: Port Jackson, intertidal, T. H. Johnston & M. J. Walker, SAM E942 & E943 (syntypes); Port Jackson, intertidal, T. H. Johnston & L. M. Angel, SAM BANZARE collection; Port Stephens, intertidal, T. H. Johnston, SAM L708; Port Stephens, intertidal, AM U672 & U673; Rose Bay, Port Jackson, AM U880; Long Reef, Sydney, intertidal, P.A. Hutchings & W.F. Ponder, 16.xi.1970, AM W22254; Port Kembla Harbour, 1 m, J. Watson, NMV F77075; Fairlight, Port Jackson, intertidal, K. Wasson & Aust. Mus. Party, 15.ii.1995, AM W22255.

Victoria: Little Henty Reef, near Apollo Bay, 2.5–8.0 m, C. Handreck, 5.ii.1994, NMV F76892.

North Island, New Zealand: Pukerua Bay, intertidal, S. O'Shea & K. Wasson, 28.i.1995, PML reference collection.

South Island, New Zealand: Cemetery Bay, Otago Peninsula, intertidal, E. Batham, 4.v.1961, PML reference collection (*P. hispida* holotype); Cemetery Bay, Otago Peninsula, intertidal, E. Batham, 4.v.1961, BMNH 1964.2.8.5 (*P. hispida* holotype); Cemetery Bay, Otago Peninsula, intertidal, E. Batham, 4.v.1961, BMNH 1964.2.8.25; Cemetery Bay, Otago Peninsula, intertidal, E. Batham, 10.xii.1962, OM Iv2010/A.64:9 (*P. hispida* paratype); Cemetery Bay, Otago Peninsula, intertidal, E. Batham, 10.xii.1962, BMNH 1964.2.8.6; Aquarium Point, Otago Peninsula, intertidal, M. Barker & K. Wasson, 4.ii.1995, PML reference collection; Aquarium Point, Otago Peninsula, intertidal, M. Barker & K. Wasson, 4.ii.1995, personal collection of K. Wasson.

Diagnosis

Stolon narrower than stalk; stolonic septa of variable thickness, but often very delicate; stalk quite thick, about three times as long as calyx;

stalk and calyx hispid; calyx wide and somewhat asymmetrical in side view; 16–36 tentacles, usually 20–24; tentacular membrane high; axial rows of large cells on abfrontal surface of tentacles, conspicuous as glistening bands in living zooids; larva small, tall and narrow, often densely coated with particles.

Description

Colony: A colony of *Pedicellina whiteleggii* resembles those of most other pedicellinids, with a network of stolons creeping on the substratum, from which the zooids arise at regular intervals (Fig. 1a). The stolons, stalks and calyces are translucent beige. New buds are formed at the

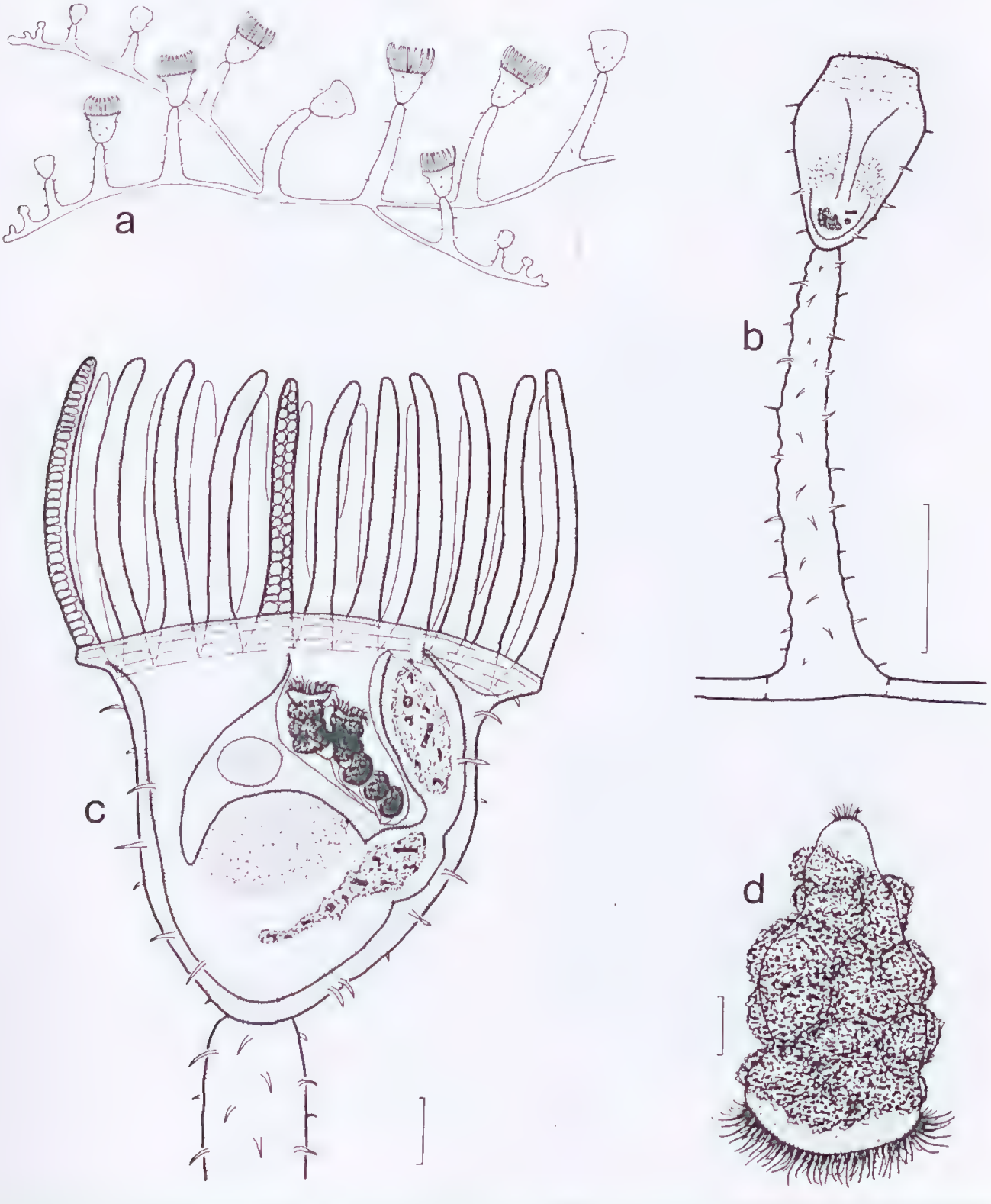

FIGURE 1. *Pedicellina whiteleggii*. **a**. part of a colony. Scale bar=1000 µm. **b**. zooid with a contracted male calyx in frontal view. Scale bar=500 µm. **c**. expanded female calyx in side view, with brooded larvae. The conspicuous rows of cells are shown on two tentacles only. Scale bar=100 µm. **d**. particle-coated larva. Scale bar=20 µm.

base of older zooids, and remain connected by a basal stolon. Calyces are deciduous, as in other stolonate kamptozoans, and at any time about 10% of the zooids in a colony are in the process of regenerating calyces that have been shed.

FIGURE 2. Two *Pedicellina whiteleggii* zooids (from Long Reef, NSW). Calyces are contracted and fixed, in side view. scale bar=200 μm.

Stolon: The stolon is always considerably narrower than the upright stalk (Table 1). The inter-zooidal stolonic distance varies within populations, but is often quite short, resulting in a high density of zooids (20–30 zooids/cm^2) on the substratum.

The septa which delineate stolon segments bearing zooids ("fertile" segments) from segments without zooids ("sterile" segments) are often unusually delicate and are sometimes so inconspicuous that they cannot be distinguished even by careful examination of the appropriate portion of the stolon. The stolonic septa in *P. whiteleggii* appear to vary in thickness even within the same colony, ranging from distinct, fairly strong septa to extremely faint or even absent septa. This sort of septal variation is not typical of other pedicellinid species, in which the septa are either always present and conspicuous, as in *P. cernua*, or always absent, as in *P. pyriformis*.

Stalk: The stalk in *P. whiteleggii* is thicker and sturdier than those of many other pedicellinid species (Figs. 1b; 2). As in other pedicellinids, the stalk is highly muscular, and living colonies are characterised by the active bending motions of the zooids' stalks. Contracted zooids, which have been preserved unrelaxed, sometimes appear to have annulate stalks.

Stalk length varies within a population, but typically the stalk is about 1.2–1.6 mm long, which is about three times as long as the calyx is high (Table 1). The stalk tapers in width from base to apex (Table 1). The stalk is invariably hispid, ornamented everywhere with cuticular spines (Figs. 1b; 2). The spines are often hook-shaped, down-curved with broad bases and narrow tips. Spine size and density vary within a population; some stalks may be sparsely covered with small spines while others are densely covered with long spines.

Calyx: The calyx is laterally compressed, being much wider in side view (Fig. 1c) than in anterior (Fig. 1b) or posterior view (Table 1). In side view, the calyx is broad and somewhat asymmetrical due to a slight aboral bulge. This bulge and the resulting asymmetry are variable within a population, and occasionally are rather pronounced.

The calyx is invariably hispid. While the size and density of calycal spines vary within populations, they are generally similar to those on the zooid's stalk.

The tentacles are extended directly above the calyx parallel to the stalk (Fig. 1c) rather than

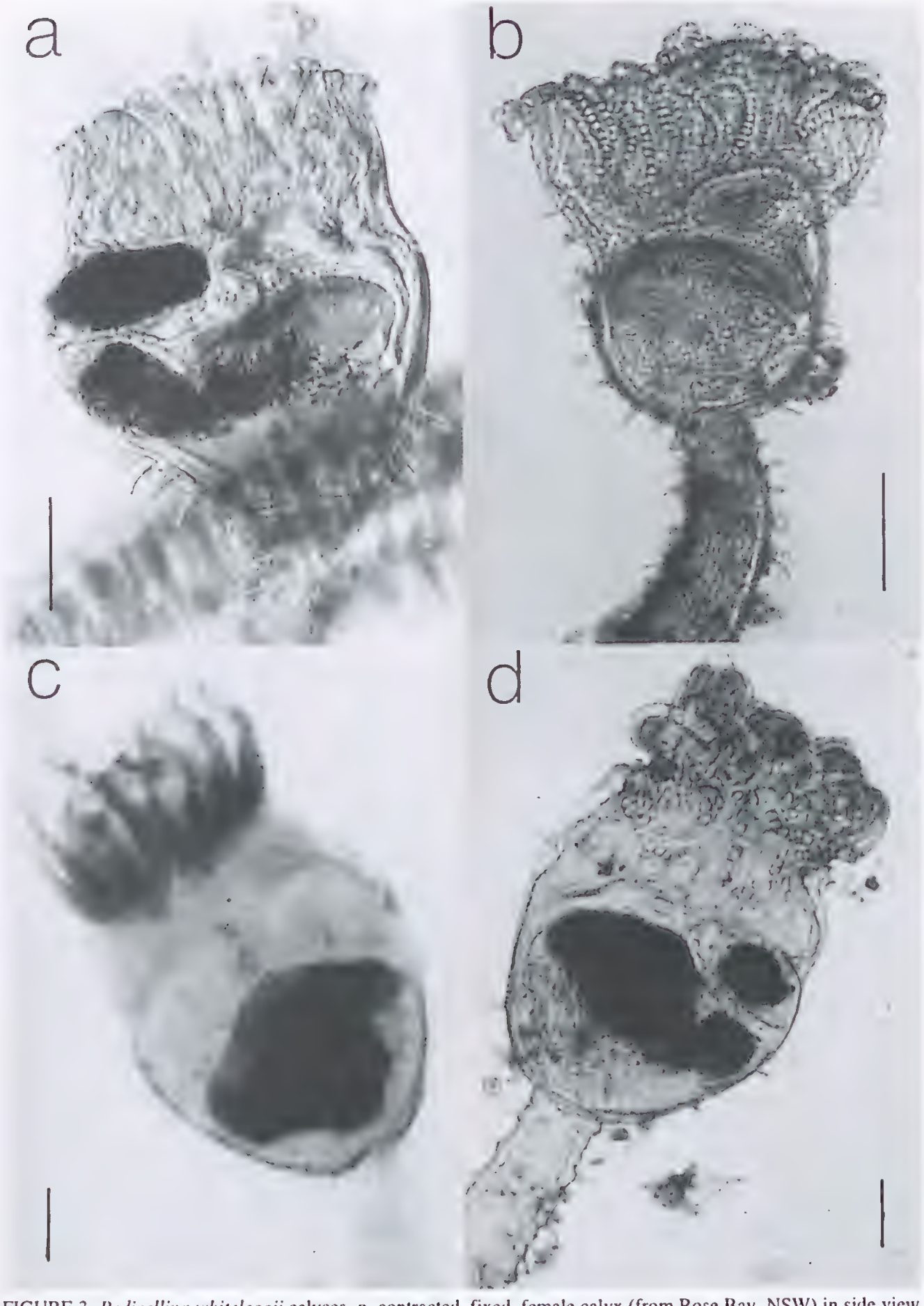

FIGURE 3. *Pedicellina whiteleggii* calyces. **a**. contracted, fixed, female calyx (from Rose Bay, NSW) in side view. **b**. contracted, live, immature calyx (from Aldinga Reef, SA) in side view. **c**. semi-contracted, live, male calyx (from Portobello, NZ) in frontal view. **d**. semi-contracted, live, immature calyx (from Fairlight, NSW) in side view. Scale bar=100 μm in a–d.

TABLE 1. Dimensions of zooidal components of *Pedicellina whiteleggii*. All measurements are given in micrometers.

Dimension	Average (adult)	Observed Range
CALYX HEIGHT (calyx base to tentacular membrane)	600	400–760
CALYX DEPTH (in side view)	500	300–600
CALYX WIDTH (in anterior or posterior view)	350	220–450
TENTACULAR MEMBRANE HEIGHT (region of conspicuous circular musculature)	75	60–85
TENTACLE NUMBER	20–24	16–36
CALYX HEIGHT/STALK LENGTH	1:3	1:2–1:4
STALK LENGTH (stolon to base of calyx)	1400	720–2600
APICAL STALK WIDTH (at calyx)	130	110–180
MID-STALK WIDTH (in middle)	160	120–280
BASAL STALK WIDTH (just above stolon)	240	160–340
STOLON WIDTH	90	60–120
FERTILE SEGMENT LENGTH	400	240–600
STERILE SEGMENT LENGTH	300	100–600
LARVAL HEIGHT (prototroch to apical organ)	150	130–200
LARVAL WIDTH (in side view)	75	60–100

tilted anteriorly as in some other pedicellinid species. The tentacular membrane is high, and in contracted calyces the tentacles appear to be deeply infolded. When living colonies are examined under reflected light, conspicuous pale yellow axial bands glisten on the tentacles. At higher magnification these bands appear to consist of two longitudinal rows of large, oval cells, on the abfrontal surface of each tentacle. (Figs. 1c; 3b; 3c; 3d). These large cells may have a glandular function. This tentacular organisation is an unusual and distinctive feature of *P. whiteleggii* which has not been previously recorded.

The shape and size of the digestive tract and its components vary somewhat with state of anaesthetisation. The mouth leads into a typical wide oral funnel which narrows into a tubular esophagus. The stomach is large, often somewhat triangular in appearance, wider on top than near the base (Fig. 3a). The intestine is a broad cylinder which narrows abruptly at the rectum. The rectum is quite broad, and sometimes widens towards the anus. The anal cone often extends obliquely, but may be folded down horizontally in a contracted calyx or extended up vertically in a fully relaxed animal.

Sexual Reproduction: Sexual reproduction probably occurs year-round. In very mature colonies, 80–90% of calyces have testes or ovaries. Since colony boundaries could not be determined, it was impossible to determine whether colonies are gonochoric or hermaphroditic. Calyces contain gonads of only one sex, and thus appear to be gonochoric, although the possibility of sequential hermaphroditism cannot be excluded. Testes are similar to those of other kamptozoans in appearance and location: large white sacs packed with sperm, lying on either side above the stomach (Fig. 1b). Females have relatively large

ovaries for a kamptozoan, located in the same position as the testes (Fig. 1c). About 12–16 embryos are clustered in a thin-walled, flexible brood chamber. The embryos seem unusually small and numerous.

The larva is relatively small (Table 1), tall and very narrow in frontal and side view (Figs. 1d; 4a; 4b). The surface of the swimming larva is densely coated with particles of apparently external origin which appear beige under reflected light and dark under transmitted light. Particles sometimes cover even larvae which are still retained in the brood chamber. Perhaps sticky secrections coat the larval surface, attracting and retaining particles. The outline of the prototroch is roughly circular when viewed from below. The larval foot and frontal organ are highly reduced or absent. As in other kamptozoans, the larval body is quite contractile.

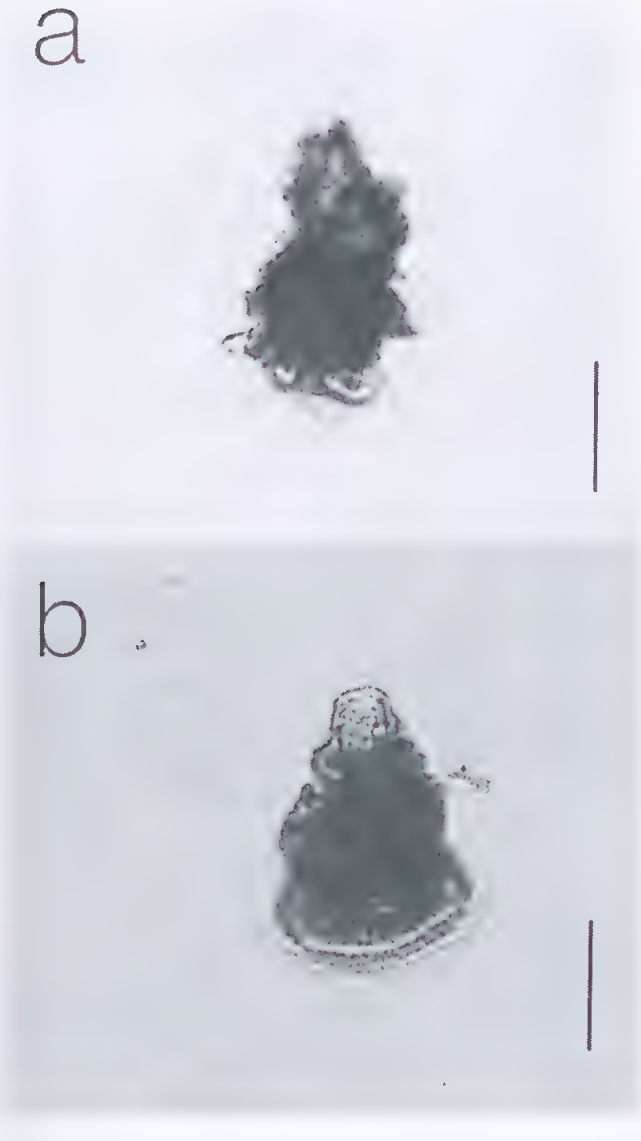

FIGURE 4. *Pedicellina whiteleggii* larvae. **a.** larva (from Portobello, NZ), probably in frontal view. **b.** larva (from Aldinga, SA), probably in side view. Scale bar=100 μm in a and b.

The form of the larva in *Pedicellina whiteleggii* is very distinctive and differs from that of other pedicellinids in which the larva is known. In both *P. cernua* and *P. nutans* the larva is much larger and much wider in side view, and has a well-developed foot and frontal organ (Nielsen 1971). While the larva of *P. whiteleggii* differs markedly from those of some of its congeners, it bears a striking resemblance in its proportions and in the dense particulate covering to the 'type A' larva described for the barentsiid *Barentsia gracilis* from European waters (Nielsen 1971). The *B. gracilis* 'type A' larva also lacks a foot and has a reduced frontal organ.

Newly settled larvae are found on or near adult colonies, suggesting that in this species, as in many or all other kamptozoans, larval settlement is gregarious.

Habitat

Colonies of *Pedicellina whiteleggii* generally occur on living substrata, including algal holdfasts, sponges, hydroids, serpulid polychaete tubes, oyster shells, erect and encrusting bryozoa, and ascidians. The most common hosts seem to be serpulids, encrusting bryozoans, and solitary ascidians. Occasionally, colonies may also grow directly on protected rock surfaces.

This pedicellinid occurs in sheltered places, such as under stones or in deep overhangs, and grows in fouling communities of hydroids, ascidians, and bryozoans. The material examined for this study was collected primarily from the low intertidal zone, with only a few specimens collected subtidally at a few meters depth. This species' distribution may well extend into far deeper water; it should be sought by examination of appropriate substrata collected by SCUBA or dredging.

Distribution

South Australia (Gulf St. Vincent; Yorke Peninsula), New South Wales (Port Jackson; Port Stephens; Port Kembla), Victoria (Lady Julia Percy Island; Little Henty Reef), and New Zealand (Goat Island Bay; Pukerua Bay; Otago Peninsula).

Pedicellina whiteleggii *and its synonyms*

Three reports of pedicellinids from New South Wales and Victoria roughly match the description of *P. whiteleggii*, but the animals are not well described or figured in these texts. MacGillivray (1887) merely noted *Pedicellina sp.* from Port Phillip Heads without providing descriptive information or a figure; but since *P. whiteleggii* is

common at that locality, his report may well be of this species. Whitelegge (1889) listed *Pedicellina cernua* from Sydney Harbour, again without a description or figure, but Johnston & Walker (1917) synonymised his material with *P. whiteleggii*. Stach (1937) identified *P. whiteleggii* from Lady Julia Percy Island off the Victorian coast, and since Johnston & Angel (1940) examined other collections he had made and found his identifications of *P. whiteleggii* correct, I also infer that his material was indeed *P. whiteleggii*.

Ryland (1965) described a new species, *Pedicellina hispida*, from New Zealand, based on three colonies growing on brachiopods in Otago Harbour, New Zealand. Examination of the types of *P. hispida* revealed that it closely matches *P. whiteleggii*: a narrow stolon with inconspicuous septa, hispid stalk and calyx, somewhat asymmetrical calyx with a high tentacular membrane. The sizes and proportions of the zooids also agree with those of *P. whiteleggii*. Live colonies I collected from Otago Harbour were clearly the same as Ryland's *P. hispida* based on zooid structure and calyx morphology. In the fresh material, I noted the rows of large tentacular cells glistening yellow under reflected light, and the tall, particle-covered larva, both characteristic of *P. whiteleggii*. These traits, taken together, justify the synonymy of Ryland's *P. hispida* from New Zealand with *P. whiteleggii*. Gordon (1972) identified a kamptozoan from the North Island of New Zealand as *P. hispida* Ryland. Based on the figure, this kamptozoan was probably also *P. whiteleggii*.

Ryland (1965) also identified colonies from Europe as *P. hispida*, but the calyces in these colonies are glabrous, while those of *P. whiteleggii* are always hispid. The tentacle and larval structure of the European colonies is not known, and so their status is uncertain. Because of this uncertainty and because their localities are so distant from Australia and New Zealand, I have excluded the European specimens of *P. hispida* from the list of synonyms of *P. whiteleggii*.

In 1940, Johnston & Angel synonymised *P. whiteleggii* Johnston & Walker with *P. hirsuta* Jullien. This decision reflected a general trend then to consider all the world's pedicellinids as variations of one species, *Pedicellina cernua* Pallas. Cori (1936) suggested that *P. whiteleggii* Johnston & Walker might be *P. cernua var. hirsuta*, described by Jullien (1891) as *P. hirsuta* from Tierra del Fuego. Although Cori had apparently never seen either Jullien's or Johnston's material, Johnston & Angel (1940) were nevertheless swayed by Cori's authoritative opinion. While they did not believe *P. whiteleggii* was a variety of *P. cernua*, they compromised by synonymizing it with *P. hirsuta*. Jullien's (1891) description of *P. hirsuta* is sketchy and there are no illustrations. The type material (Muséum National d'Histoire Naturelle, Paris) consists of five dried zooids on natural substratum (Bry–2177) and a slide mount of five other zooids (Bry–39), of which four are recently budded, tiny zooids at the stolon tip. My examination of this type material suggested that this species, while resembling *P. whiteleggii* in general shape and in the hispid stalk and calyx, is distinct from it. Based on these ten poorly preserved zooids, *P. hirsuta* has a wider stolon that is hispid in places, which contrasts with the narrow, glabrous stolon of *P. whiteleggii*. The stalk tapers less in *P. hirsuta* than in *P. whiteleggii*, and the spines on the *P. hirsuta* types are longer and denser than is typical for *P. whiteleggii*. Most conclusively, the tentacles of the type specimens did not contain the conspicuous large cells found in *P. whiteleggii*. The larval form of *P. hirsuta* remains unknown, because the only sexual mature zooids in the type specimens were male. Since there is no evidence for synonymy with *P. hirsuta* Jullien, *P. whiteleggii* now reverts back to its original 1917 name.

Other pedicellinids from Australia and New Zealand

***Pedicellina compacta* Harmer, 1915**: This species was reported from the Great Barrier Reef by Hastings (1932). Her material (BM 1932.4.20.93) and additional colonies I collected in Rowes Bay, Townsville, Queensland (MTQ G21264) are certainly referable to Harmer's *P. compacta* (BM 1916.8.23.33–34) from the Aru Islands (Indonesia). *P. compacta* apparently replaces *P. whiteleggii* as the ubiquitous coastal species in tropical and sub-tropical waters. *P. compacta* has much smaller zooids than *P. whiteleggii*, with total zooid height (stalk and calyx together) averaging 600–800 µm. The stolon is extremely narrow (30–40 µm) and the stolonic septa are much more conspicuous than in *P. whiteleggii*. The stalk tapers much less between base and apex, and is proportionately shorter, typically one to two times as long as the calyx is high. The stalk is very muscular and mobile. The proportionately big calyx (but still only about 300 µm high!) is narrower in side view than in *P. whiteleggii*; it is not as compressed laterally. The calyx and tentacles show a slight anterior tilt

absent in *P. whiteleggii*, and there are only about 12–16 tentacles. The calyx and stalk are covered by filiform, cylindrical, extremely long spines that are completely different from the shorter, thicker, hook–like spines of *P. whiteleggii*.

***Pedicellina pyriformis* Ryland, 1965**: This exquisite species forms the tallest and densest colonies known for any pedicellinid. It was described by Ryland (1965) from the Otago Peninsula. I have examined his material (PML reference collection; OM Iv2008–9/A.64:7–8) as well as a colony collected by K. Gowlett-Holmes (SAM PH 0008) from Tasmania. The stolon is very much wider than in *P. whiteleggii* and is completely non–septate. The stalk is listed by Ryland as being about 2 mm long, but a colony from Otago deposited at PML after his study was completed has stalks reaching an astonishing 5–6 mm. The stalk tapers only very slightly from base to apex, and both calyx and stalk are glabrous. The triangular calyx is much less laterally compressed than in *P. whiteleggii*, and is not asymmetrical in side view. The calyx is typically 600–700 µm high, but in some cases attains a height of 1 mm. The gut is also distinctive: the stomach is compact and triangular, and the intestine and the rectum are long and narrow, the latter extending within an anal cone high into the tentacular crown. The gut has empty spaces around it rather than filling the calyx as in most other pedicellinid species.

***Pedicellina grandis* Ryland, 1965**: This species was described from one colony from Otago Harbour. This colony (PML reference collection; OM A.64:6) resembles *P. whiteleggii* in general form. The stolon is narrow and the septa inconspicuous; the stalk and calyx are hispid. The main difference between *P. grandis* and *P. whiteleggii* appears to be quantitative: some *P. grandis* zooids have considerably longer stalks than do *P. whiteleggii* zooids. Ryland (1965) also noted that the tentacles in semi–contracted calyces form a distinctive conical cap, but this trait appears to vary with the state of zooidal relaxation. Further examination of the tentacle structure and larval form of this species may reveal further distinguishing features which separate the two species, or, on the other hand, that *P. grandis* is synonymous with *P. whiteleggii*, and that its longer stalks can be attributed to habitat or age differences.

***Pedicellina pernae* Ryland, 1965**: This species from Otago is distinguished from *P. whiteleggii* by its somewhat smaller size and a glabrous or only sparsely hispid calyx. Ryland (1965) noted that the calyx was more asymmetrical than that of *P. hispida* (=*P. whiteleggii*), but my examination of the types (PML reference collection; OM Iv2011/A.64:10) revealed that the calyx shape falls within the range of variation of *P. whiteleggii*. Ryland (1965) himself noted that this species lacks really distinctive features. Collection of living material and examination of tentacle structure and larval form could reveal whether this is indeed a different species than *P. whiteleggii*.

***Pedicellina cernua* (Pallas, 1774)**: This cosmopolitan species occurs mainly in bays and harbours. Kirkpatrick (1890) found this species in Port Phillip, Victoria. Chittleborough (1952) reported *P. cernua* from a community of primarily introduced species at Port Adelaide and Outer Harbour, South Australia, and it is probably present in other harbours in Australia and New Zealand. Kirkpatrick's (BM 1888.5.17.24) and especially Chittleborough's material (SAM L713–718) have many features which distinguish the cosmopolitan *P. cernua* from the indigent *P. whiteleggii*. The stolonic septa in *P. cernua* are more clearly visible. The stalk is narrower and tapers more gradually from base to apex. The stalk is hispid, and the spines longer than in *P. whiteleggii*, although this feature is variable. The calyx of *P. cernua* is wider in side view, almost as wide as high, and its aboral bulge and consequent asymmetry are more pronounced. The tentacles in *P. cernua* are tilted anteriorly. The tentacles lack axial rows of large cells, although there is dark green granular pigmentation in the tentacles of some zooids. The tentacular membrane is not so high as in *P. whiteleggii*. A more striking difference is the consistent absence of spines from the calyx. The rectum in *P. cernua* generally appears narrower and extends higher into the tentacular crown than in *P. whiteleggii*. The brood chamber of *P. cernua* is lobulate, while that of *P. whiteleggii* is not. As already discussed, the larva of *P. cernua* differs from that of *P. whiteleggii* in being larger, wider in side view, in having a well–developed foot and frontal organ, and in lacking a dense particulate covering (Nielsen 1971).

Discussion

Knowledge of pedicellinids from Australia and New Zealand is rather limited. This is certainly not because the animals are rare or hard to find; only a few hours in the field turned up many colonies at every site I visited.

The diversity of Australian and New Zealand pedicellinids is low. There appears to be one

ubiquitous coastal pedicellinid (*P. whiteleggii*) in colder waters and another (*P. compacta*) in warmer regions, one cosmopolitan species in harbours (*P. cernua*), and one other distinctive species (*P. pyriformis*) in southern areas. Other unreported and perhaps undescribed species will surely be found in unexplored habitats (e.g. deeper water) or unsurveyed regions (e.g. Western Australia). In Northern Europe, which has been much better surveyed for kamptozoans, there is also a low diversity of pedicellinids; only one or two common species and a few rare ones. It is difficult to compare the species diversity of pedicellinids from Australia with other regions, since the pedicellinid fauna of most parts of the world has not been characterised.

The distributions of the pedicellinids found in Australia and New Zealand seem fairly large. *Pedicellina pyriformis*, known only from Otago and Tasmania, appears to have the most limited range, but this rare species may yet be found in other areas. The distribution of *P. whiteleggii* includes much of New Zealand and southern Australia, but its western and southern limits are not known. *P. compacta* is found from Indonesia to Queensland. And *P. cernua* has been reported from all over the world. Only more thorough taxonomic surveys will delineate these ranges more adequately.

The taxonomy of pedicellinids (and of tiny, soft–bodied creatures in general) always poses challenges because of the apparent paucity of morphological characters. Historically, kamptozoan taxonomy has been based on adult traits. Larval form has been largely ignored (but see Nielsen 1971), although since all kamptozoans brood, and most are reproductive year–round, larvae are usually easy to obtain. Larvae can also be examined in well–preserved museum specimens. In this study, a distinctive larval form enabled museum and the field material in Australia and New Zealand to be united under one name, and helped to separate *Pedicellina whiteleggii* from *P. cernua*. In the future, pedicellinid taxonomy would be strengthened by inclusion of larval traits in species descriptions.

Acknowledgments

I am grateful to P. Arnold, E. & M. Barker, P. Berents, K. L. Gowlett-Holmes, J.-L. d'Hondt, S. O'Shea, S. A. Shepherd, M. Spencer Jones and W. Zeidler for their generous assistance in accessing museum collections and in carrying out field work. J. S. Ryland's excellent study of pedicellinids from New Zealand was a resource and an inspiration for this work. I am indebted to C. Nielsen for drawing my attention to the usefulness of tentacle structure and larval form in kamptozoan taxonomy. A. T. Newberry and D. Potts provided invaluable assistance in the preparation of the manuscript. Thanks also to C. Glasby and the Australian Nature Conservation Agency for support of this research.

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MYTH AS HISTORY? THE NGURUNDERI DREAMING OF THE LOWER MURRAY, SOUTH AUSTRALIA

PHILIP A. CLARKE

CLARKE, P. A. 1995. Myth as History? The Ngurunderi Dreaming of the Lower Murray, South Australia. *Records of the South Australian Museum* **28**(2): 143–157.

The ethnographic record of Aboriginal mythology in the Lower Murray cultural region of South Australia provides a number of accounts which describe the activities of the main 'Dreaming' ancestor, Ngurunderi. Rather than attempting to standardise the cultural data, this diversity is used here to examine Aboriginal perceptions of the landscape that reflect differing world views. Although the literature acknowledges the important religious dimension of these creation myths, the socio-political dynamics have hitherto generally been dismissed. This paper demonstrates that it is part of the essential nature of mythology, and its associated site-related data, to be flexible and constantly altered and appended. Here is a study of cultural geography, which considers both the material and non-material aspects of Aboriginal cultural construction of the landscape.

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Introduction

In pre-European Australia, Aboriginal people perceived the social and physical aspects of their world to be closely interwoven. They believed that their spirit ancestors had imbued the landscape with social relevance, and had thereby humanised it. The southern Australian ethnographic literature generally distinguishes between myths that focused on events said to have occurred during the 'Dreaming' or 'Dreamtime', when the main 'creation' took place, and those that concern the period afterwards. The 'Dreaming' in the Lower Murray region was referred to as the *Kulhal* or *Gulal* (Berndt 1940: 170; Berndt & Berndt 1981: 229). Ronald and Catherine Berndt record that the *Kalalwu* or *Kalalal* reportedly meant 'long ago' (Berndt & Berndt 1993: 75, 242). Mythology gained from enlightenment through actual dreams was termed *pekeri* (Berndt & Berndt 1993: 213, 214). The Dreamtime represents an Aboriginal English gloss of a range of meanings. The 'Dreaming' can loosely be defined as the whole body of mythology in Aboriginal Australia that provides some insight into significant cultural events. The form of 'history' that the Dreaming provides is generally portrayed in the popular literature as a monolithic entity, without the possibility of revision or reinterpretation. Under this model, adhered to by both Aboriginal people and some early scholars, such history (or 'tradition') is not changed, only forgotten. Here I follow the work of Kolig (1984 [1981]), Myers (1986), and Sutton (1988), and take a more flexible view of Aboriginal Dreaming, showing it to be a text that reflects the dynamism of culture.

This paper follows the argument put forward in a previous work that mythology provides an image of the dynamic aspects of cultural relationships to landscape (Clarke 1991a: 66–69). Here, the development of tradition is treated as a constant process of re-evaluation of the links between present and past. In this context, I begin by considering the variations occurring within a major creation myth, that of Ngurunderi. As discussed by Maddock (1976) in reference to myths in northern Australia, the local variations form a universe of discourse in which their owners collectively determine what is in common to them all, and through which new possibilities are introduced. The differing versions are not just answers to varied life situations, but are put forth by Aboriginal people as responses to each other. I demonstrate how this process continued in the Lower Murray, under the new socio-political dynamic of post-European colonisation, creating a proliferation of 'new' versions of important myths. The cultural geography concept of the 'cultural landscape' considers the physical and perceptual elements of landscape that are absorbed by other,

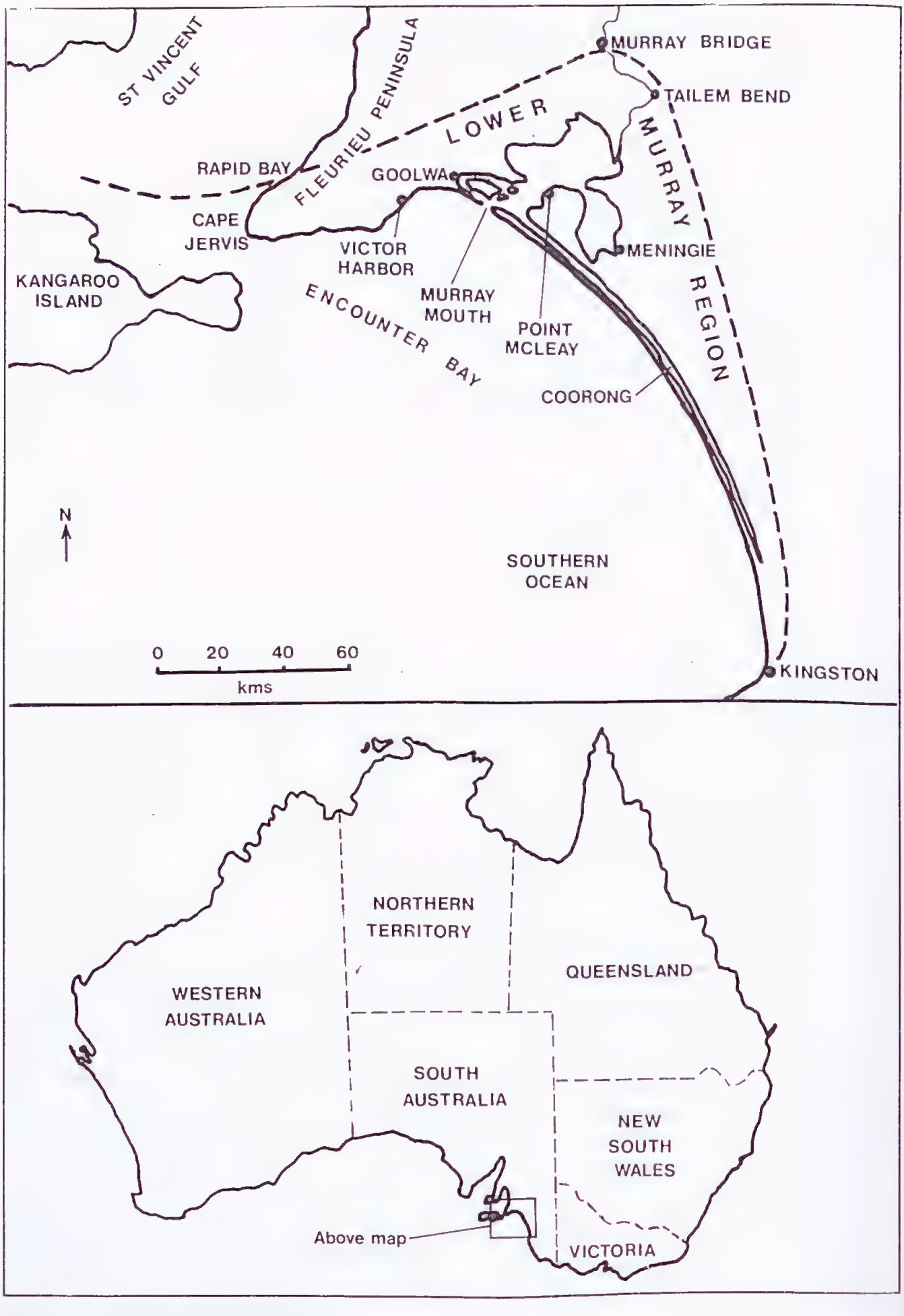

Figure 1. The Lower Murray cultural region.

usually successive, cultural groups. It is useful here to provide a framework of evaluating continuity.

The Lower Murray cultural region may be defined as the area bounded by Rapid Bay in the west, across to the southern side of Murray Bridge, and south to Kingston (Fig.1). It takes in the southern part of the Fleurieu Peninsula, all of Encounter Bay, Lake Alexandrina and Lake Albert, and the Coorong. In the early years of European settlement this region was noted by several observers to be relatively culturally homogeneous in relation to neighbouring groups that differed in language, custom and material culture (Meyer 1843: vi; 1846 [1879: 185]; Cawthorne 1844 [1926: 1]; Mathews 1898: 336–343). Rather than comprising a few large units that past scholars have labelled as 'tribes', it is better to treat the Lower Murray people in the early years of European settlement as a more numerous series of extended family units, headed by several politically active people who led by their coercive powers over others (Clarke 1994, Chapter 2). These land-owning units were descent groups tracing their origins to particular locations of mythological significance in their territory. In most parts of Australia, these places are usually termed 'sacred sites' (Berndt 1970; Myers 1986: 50, 51, 134–136). An individual's connection to the Dreaming provided the basis of his or her identity. Marriage and trade relationships helped the Lower Murray groups maintain a high degree of social and cultural cohesion. Because of a number of factors, the Ngarrindjeri people have retained their regional and cultural distinctiveness up to the present (Jenkin 1979; Hemming 1988; Hemming *et al* 1989; Clarke 1994). Due in part to the close proximity of this region to Adelaide, the Aboriginal people from the Lower Murray continue to have a major role in Aboriginal affairs in South Australia.

Contact Between Europeans And Aboriginal People

Aboriginal groups in South Australia were influenced by Europeans long before official settlement in 1836. The first significant effect of European settlers on South Australian Aboriginal populations was probably the introduction and spread of smallpox from eastern Australia, reaching the Lower Murray along the river system in two waves sometime between 1814 and 1820, and between 1829 and 1831.[1] In the mythology of the Lower Murray, smallpox is linked with the ancestral spirit, Kulda, who came from the Southern Cross constellation foretelling death (Tindale 1931–34: 251, 252; 1937: 111, 112; 1941: 233, 234). The devastation this brought to indigenous populations, and the effect upon their culture, can only be guessed at.

The activities of whalers and sealers, operating chiefly out of Bass Strait, and their effect upon the southern Aboriginal populations, warrant a mention here. These men, some of whom were dwelling on Kangaroo Island as early as 1819, lived outside colonial control then based in Tasmania (Clarke 1990 MS; 1994: 192–203). They periodically raided the mainland for Aboriginal women to serve as labourers and wives. Some of these Kangaroo Island men had trading relationships with mainland Aboriginal groups, in particular those in the Lower Murray region. Therefore it is likely that most southern South Australian Aboriginal people had some knowledge of Europeans before official settlement in 1836, even if only indirectly, and had rationalised this incursion within their own cosmological views. With the range of contacts discussed above, both indirect and direct, we must acknowledge that the early southern South Australian ethnographies, however skilfully obtained, do not provide strictly pre-European accounts of Aboriginal society.

Since official settlement by Europeans in South Australia in 1836, Aboriginal people in the southern agricultural districts have gradually become marginalised in respect to land. During the nineteenth century, Aboriginal people in the Lower Murray worked as fishermen, shepherds, and as labourers to bring in the harvest (Clarke 1994, Chapter 6). By the early twentieth century, most were forced into living at mission stations governed under restrictive legislation. Due primarily to the break-up of the pastoral stations in the region at this time, Aboriginal hunting and gathering activities were chiefly restricted to the Coorong area where Aboriginal reserves and vacant crown land still existed (Clarke 1994, Chapter 8). For this reason, contemporary knowledge of the landscape retained by Aboriginal people relates mainly to the southern parts of the Lower Murray region. A broader Aboriginal cultural identity formed from the social environment of enforced interaction between formerly separate groups from throughout South Australia. Aboriginal people started identifying themselves more according to mission settlements, rather than as territorial-based descent groups. Since the 1960s, when many of the legal

restrictions were removed, Aboriginal people have moved into rural town centres in the Lower Murray, with a large number of Ngarrindjeri people living in Adelaide (Inglis 1961; Gale 1969; 1972; Gale & Wundersitz 1982; Schwab 1988).

The detailed recording of Aboriginal culture in the Lower Murray starts with the German missionary Meyer who was active in the Encounter Bay region during the late 1830s and early 1840s (1843; 1846). During the 1870s the writings of Taplin, based at the mission of Point McLeay on the southern shore of Lake Alexandrina, focused the attention of northern hemisphere scholars upon the Ngarrindjeri.[2] Nineteenth century missionary records are to some extent balanced by the recordings of Penney (1840–43 [1991: 1–107]), Cawthorne (1844 [1926]), Moorhouse (1843 [1990]; 1846), Angas (1847a; 1847b), and Wyatt (1879). During this century, various anthropologists such as Brown (1918), Tindale (1930–52; 1931–34; 1934–37; 1935; 1937; 1938; 1938–56; 1941; 1981; 1987; Tindale & Mountford 1936; Tindale & Pretty 1980), Harvey (1939; 1943), and the Berndts (Berndt 1940; Berndt & Berndt 1993) have studied this Aboriginal culture. The attention that these scholars have directed towards the Lower Murray has meant that it is ethnographically one of the best described regions in southern Australia.

Ngurunderi: An Aboriginal Dreaming Of The Lower Murray

The mythology of Ngurunderi touches upon most aspects of Aboriginal life. Preeminent in the anthropological record of the Lower Murray, he is a major 'spirit creator' credited with shaping the region's topography and distinctive culture. The myth provides an explanation of the landscape, not only the formation of features such as The Bluff at Victor Harbor and the course of the Murray River, but the distribution and characteristics of particular plant and animal species. For example, Ngurunderi's actions were thought to have resulted in the present distribution of the pigface plant, an important food resource (Tindale 1931–1934, vol.1: 186; Berndt 1940: 179; Berndt & Berndt 1993: 226). Another illustration of his perceived creative powers was to give the bony bream fish its numerous fine bones (Education Department of South Australia 1990: 56–58). His body parts are represented in the landscape; his legs form the Sir Richard and Younghusband Peninsulas at the Murray Mouth for instance (Berndt & Berndt 1993: 13; Clarke 1994: 114, 115). Thunder was regarded as Ngurunderi's voice, rainbows showed him urinating (Taplin 1874 [1879: 58]). Customs attributed to Ngurunderi's law include the prohibition of young male initiates eating certain types of Murray cod, considered to be 'Ngurunderi's fish' (Tindale 1934–1937, vol.2: 39). He and his son Matamai are also credited with introducing mortuary rites to the Lower Murray people, involving smoking the dead (Tindale 1934–1937, vol.2: 51; Berndt 1974: 26, 27; Berndt & Berndt 1993: 227, 228). Through association with Ngurunderi and Matamai, desiccated bodies were considered to be sacred objects, at least until the rites were completed.

Ngurunderi was perceived to have power over both the living and the dead. Taplin records a discussion with an Aboriginal man, Captain Jack:

> He thinks death to arise from sorcery when caused by sickness, but to be by the special interposition of Nurundere when caused by spear or waddy wounds. He says Nurundere invented the waddy and spear and boomerang, and wimmera [sic.] and plonggee [small club] long ago. And it appears that they regard him as a sort of war-god (Taplin Journals, 20 October 1859).

To die as the result of injuries due to fighting was considered by the Lower Murray to please Ngurunderi (Taplin Journals, 19 January 1860). It was believed that after death, Ngurunderi guided the souls of Lower Murray people to the 'Lands to the West'. Here they would live in huts around him. The Raminyerar considered that they would reside in Ngurunderi's hut, with other descent groups in neighbouring shelters (Meyer 1846 [1879: 206]).

Episodes of the Ngurunderi creation epic were acted out during dances. Taplin recorded that one night:

> Two of their songs in particular attracted my attention. One was called "The Nurundere", and is about God ... [It] began with a low chant as if they were chanting Latin. However, all through the piece they say the same words over and over again, then the chant rose higher and higher with beat of the tartengk a native drum, then it sank again and the men's voices broke in shouting in time to the chant and brandishing the weapons with tartengk. Then the shrill treble of the women broke in like an imploring vociferation in answer to the shouts of the men. These ceased, and the whole concluded with a loud chant to the beat of the tartengk and drum. The latter piece was to slower time, and was very plaintive and wild (Taplin Journals, 30 June 1859).

The passage of Ngurunderi through the

territories of certain descent groups during the Dreaming had perceived implications for Lower Murray marriage relationships (Turner 1980: 6). This mythology was so much a part of the Lower Murray cultural system that to a large degree an individual's possession of detailed knowledge concerning it helped locate that person within particular parts of the region.

From descriptions of the myth that stress warfare, Ngurunderi appears to have had special significance to men. Nevertheless, he was of much wider importance as the creator of Lower Murray culture. In contrast to more northerly regions the available accounts of Aboriginal ceremonial life in the Lower Murray indicate that there was a large degree of sharing of knowledge between men and women. Tindale (1934–1937, vol.2: 223) states that in the Lower Murray some old women were allowed at the *Narambi* secret initiation ceremonies. Women were given a say at major meetings, and were considered to have had a *miwi* (spirit) as strong as a man's (Berndt & Berndt 1993: 71, 285). The extreme separation of the male and female realms appears to be a distinctive characteristic of the Central Australian region.[3] Elsewhere, such as in parts of the Lake Eyre Basin, women participated in many of the same ceremonies as men.[4] Similarly, in the Lower Murray region Aboriginal women had traditional authority, being the partners of men in tribal lore (Berndt 1981: 181, 182; 1982: 50). This is not to say that women and men did not have differing perspectives on some aspects of cultural knowledge. Generally, only younger people would have been excluded from secret-sacred categories of information.

The southern Aboriginal ethnographies show considerable variation in mythology, even from within linguistically and culturally similar areas.[5] In the South Australian region of the Murray Basin, there are creation accounts for the river that variously involve the different mythic heroes Nurelli, Ngurunderi, Korna and Thukabi.[6] There are even major variations within the records of Nurelli and Ngurunderi, particularly in relation to sites. In the case of the complex of mythology associated with Ngurunderi, it has been argued that the variations were simply accounted for by each Ngarrindjeri group only knowing in most detail that segment of the Ngurunderi epic relating to their own area (Hemming 1988). Contrary to this approach, which attempts to reconcile cultural differences, I argue that the diversity of these beliefs, many in direct opposition to others, can be explained in terms of the dynamic relationship people had with the landscape. Local knowledge generates alternative sites where certain events were perceived to have taken place, therefore producing distinct versions.

The existence of many versions of the Ngurunderi myth provides further evidence that the 'tribe' model of Aboriginal social structure as used by Tindale in his southern South Australian ethnographic work, is too simplistic.[7] For example, in his treatment of the Tjilbruke mythology of the Fleurieu Peninsula, Tindale selectively garnered segments of myth from various informants from the Lower Murray and Adelaide regions into one form recognised by the 'Kaurna tribe' (Tindale 1987; Clarke 1991a). But by doing this he effectively produced yet another variation, one that would never have been elicited from a single Aboriginal source. It is more productive to treat this variation in the ethnography as a pre-European characteristic of the body of knowledge that 'explained' the world. In spite of the apparently confusing number of creation accounts, there are some common elements of the mythology within the Lower Murray region that distinguish it culturally from surrounding regions.

For the Aboriginal groups of the Lower Murray, the main creator of the landscape is generally recorded in the ethnographic literature as Ngurunderi, or one of the many linguistic variations of the term.[8] The different versions of the Ngurunderi mythology generally fall into two categories – those that have a coastal bias, and those that emphasise the inland aspect of the Murray River.[9] The former versions were chiefly recorded from coastal groups away from the river in the western and south-western side of the Lower Murray, the latter from Lower Lakes people on the north-eastern end near the entrance of the Murray River into Lake Alexandrina. I will now describe this variation.

Amongst the earliest recorded myths in southern South Australia was a Ngurunderi account recorded by Penney in 1844 from the Encounter Bay people, concerning the formation of the Lower Murray landscape.[10] In this version, Ooroondooil (= Ngurunderi) was the first great spirit to wake. Three or four other beings later woke, some complaining that they were hungry and cold. Ooroondooil told one spirit to make a fish, and he taught them how to cook it. He made the lesser spirits go off to collect firewood, water and other necessary items. Ooroondooil then sent the spirits away to lands he was creating. Ooroondooil himself went westwards where he

first made the 'Big Murray people' (Coorong groups), and then the groups further west. After teaching the Lower Murray people their customs, he left, swimming to other lands in the west. Two of his wives drowned while trying to follow him, becoming the Pages Islands of the Backstairs Passage. Ooroondooil created Kangaroo Island, and then went further west where he was believed to have still lived. In a variation of this account, Ooroondooil had three wives who drowned when, due to their curiosity, they tried to reached Kangaroo Island from the mainland.[11]

In another Encounter Bay version of the Ngurunderi mythology recorded by Meyer from the Raminyerar descent group, several important mythological events had already taken place before his arrival (Meyer 1846 [1879: 205, 206]). In this rendering Ngurunderi was a large and powerful man with two wives and several children. On one occasion his wives fled from him. He chased them along the southern Fleurieu Peninsula coastline and while doing so created many of the geographic features there. He finally caught the women and beat them, but they escaped again. This time he tired of chasing them and ordered the sea to flow and drown them. They became rocks a few metres from the shore that can be seen at low tide.[12] After he had transformed the landscape, Ngurunderi was said to have gone west. One of Ngurunderi's sons who was accidentally left behind found his way to the land 'towards the west' by catching hold of a line thrown by Ngurunderi, which was attached to his testicles. In this account, the creation of new rivers, hills and other features ceased after Ngurunderi left the Lower Murray.

The versions of Ngurunderi recorded from the Lake Alexandrina descent groups vary in much of the detail from those of Encounter Bay. In one account from the Lake area obtained by George Taplin, there were once three great hunters, Ngurunderi, Nepeli and Waiyungari.[13] As evidence for their hunting prowess, numerous salt lagoons around Lake Alexandrina were considered to have been created by Nepeli and Waiyungari while pegging out fresh kangaroo skins, thus denuding these places of grass.[14] On one occasion, Ngurunderi and his sons drove an enormous Murray cod, Pondi, down the Darling and Murray Rivers to Piltangk, on the southern shore of Lake Alexandrina. Here they obtained the assistance of Nepeli. They eventually caught Pondi near Raukkan. Ngurunderi tore it into pieces, throwing each fragment back into the water, and thus creating different species of fish. The fish-making episode differs from the Encounter Bay mythology, where this is performed at a salt water locality by another spirit named Pungngane (Meyer, 1846 [1879: 202]). Ngurunderi had four children by two wives. Once, while camping at Tulurrug (Pelican Point), two of his children strayed into the eastern scrub and were lost. Ngurunderi's two wives later fled and Ngurunderi followed them to Encounter Bay where, seeing them in the distance, he drowned them by making the waters rise. He then searched up the Coorong for his two lost children and came across them after he fought and killed a sorcerer at Salt Creek. Ngurunderi later left the lower landscape for Wyirrewarre, the Sky World, taking his children with him. Although recorded as a myth, Taplin clearly considered the possibility that 'creators' such as Ngurunderi were once actual people. For example, he refers to Ngurunderi as a 'deified chief' (1874 [1879: 58]). To Taplin, myths were corrupted versions of history.

In the Lower Lakes district, away from the sea, the creation of the Lakes was given greater emphasis. Angas provides a version in which the two wives of Oorundoo (= Ngurunderi) 'proved untractable [sic], and ran away from their lord; and to punish this unwarrantable behaviour on their part, Oorundoo very properly made two lakes to drown them, which correspond with the lakes Alexandrina and Albert' (Angas 1847a: 96, 97; see Fig. 2 of this paper). Another version, possibly derived from Angas and Europeanised, states:

> The Murray dragon, Oorundoo, first caused that great river to flow. Having fallen out with his two wives, who must have been dragonesses of a huge size, and not accustomed to water exercise, that Blue Beard of New Holland constructed two lakes, at present known as lakes Victoria [= Alexandrina] and Albert, so that he might effectually drown his partners, who had actually attempted to elope from him with somebody else.[15]

Thus there are accounts of the creation of Lake Albert and Lake Alexandrina that contain elements similar to those of the Ngurunderi mythology as recorded at Encounter Bay. However, these versions makes the mythology more relevant to descent groups such as the Piltinyerar, living in the Lower Lakes and Murray River region, by giving prominence to places contained within their own mythic landscape.

The most detailed published description of the Ngurunderi myth is provided by Ronald Berndt, chiefly from his main Lower Murray informant, Albert Karloan, a Yaraldi-speaker of the Manangki descent group.[16] Like other accounts

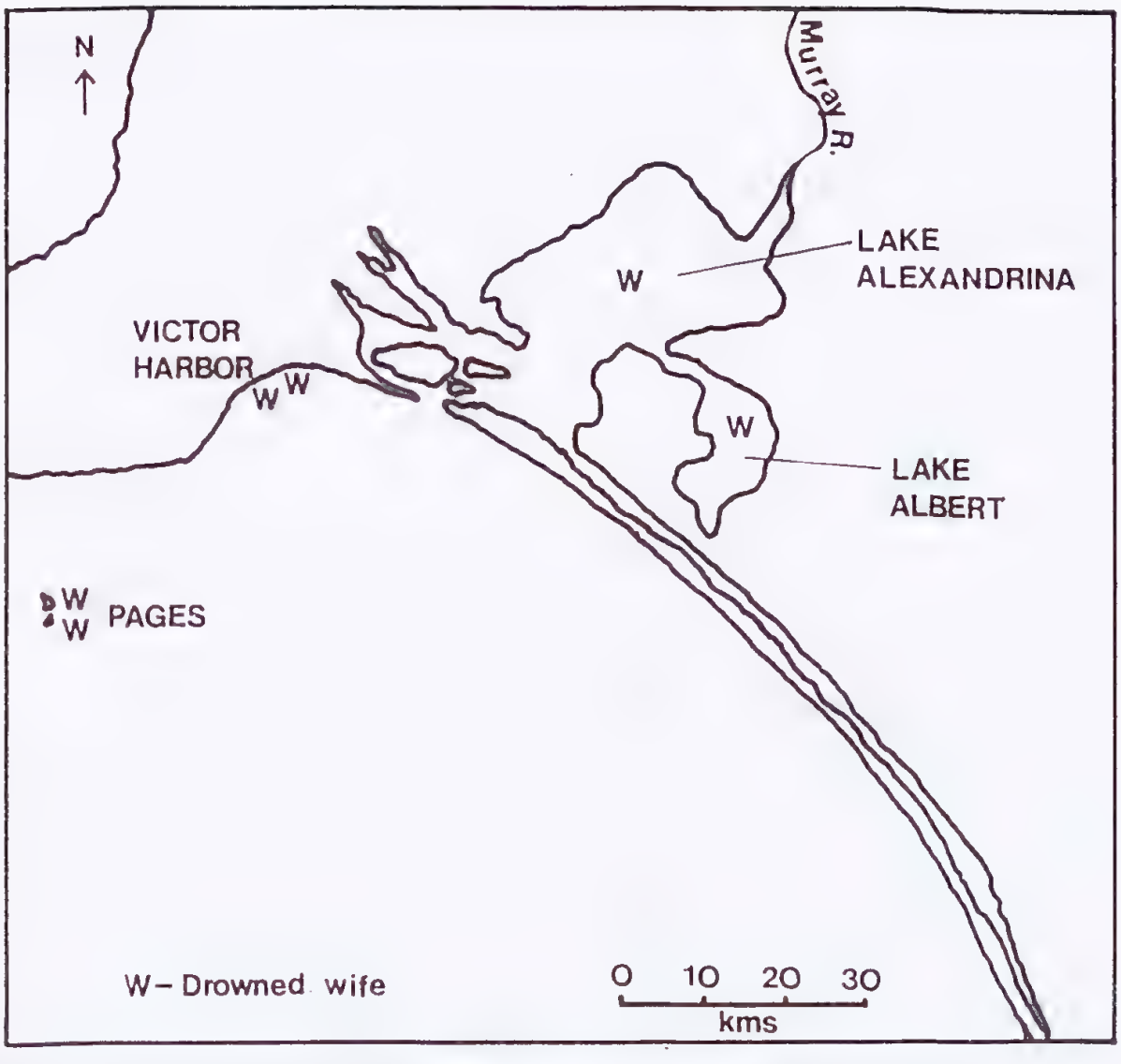

Figure 2. The wife-drowning sites of the Ngurunderi myth, showing inland and coastal variation.

published by anthropologists, he focuses on the cosmological and creation aspects of the mythology. In this version, Ngurunderi pursued the giant Murray cod Pondi down the previously narrow bed of the Murray River. As the cod was chased, it widened the river to its present width. With each sweep of the tail Pondi created a swamp. When Pondi escaped into Lake Alexandrina Ngurunderi called out to his brother in-law, Nepeli, to spear the cod. Nepeli speared it near Raukkan (Point McLeay), dragging the fish to a submerged sandbank to wait for Ngurunderi. Upon reaching Nepeli, Ngurunderi cut up the fish into many small pieces. Each portion became a different species of fish as it was thrown back into the water. In a later episode of this long account, Ngurunderi's two wives broke a food taboo and fled across the Lake Albert country, heading down the Coorong. Ngurunderi followed and near Blackford, which is inland from Kingston, he came across a sorcerer with whom he quarrelled.[17] Ngurunderi killed him and burnt his body which formed the Granites near Kingston. Ngurunderi went back along the Coorong, eventually crossing the Murray Mouth and moving along the southern Fleurieu Peninsula coast. He created many of the landscape features along the way. Ngurunderi finally found his wives crossing to Kangaroo Island and drowned them by making the seas rise. The bodies of the wives became The Pages islands. Ngurunderi then ascended to the Sky World, Waieruwar, via Kangaroo Island.[18]

Tindale provided other accounts of the Ngurunderi mythology.[19] His main published version was distilled from recordings he obtained from many Aboriginal people with varying backgrounds, including the Maraura of the Upper Murray cultural region, the Ngaralta and Nganguruku of the Mid-Murray, and down-river to the Lower Murray groups such as the Portaulun, Jarildekald (= Yaraldi), Ramindjeri and the Tanganekald (= Tangani). It is interesting

to view Tindale's printed version of this mythology compiled this century, in the light of the considerable variation in the earlier records. Not only did Tindale standardise the name of Ngurunderi, he appears to have chosen particular accounts of episodes over others with which they would have conflicted. Although very similar in its general outline to Berndt's recorded version, Tindale's explanation of some events, such as what happened to Ngurunderi's canoes, does not fit Berndt's account. However, both Berndt and Tindale shared the same Yaraldi-speaking informant, Albert Karloan.

The discussion indicates that there were many versions of the Dreamtime events within the Lower Murray region which reflected local biases. This suggests that the sites Aboriginal people insert into their accounts of the Dreaming are 'places' upon which are built both local and broader regional identities. The term 'place' refers to a humanistic concept within human geography that focuses upon the culturally determined values of particular parts of the landscape (Relph 1976; Buttimer 1980). Places are fusions of human and natural order and are the significant centres of the experiences people have of the world. They can evoke a sense of belonging to a social group and provide a sense of group identity. It is likely that some Lower Murray people, as elsewhere in Australia, even inserted themselves into the 'Dreaming' accounts of the landscape they experienced.

Age and perhaps gender were other factors in determining what mythological details were known by individuals, and what emphasis they were given. The Dreaming therefore reflects some socio-political aspects of Aboriginal life. This is consistent with the Dreaming epics recorded from other parts of Australia (Myers 1986: 60; Berndt & Berndt 1989: xxvi). Although on one level this appears to contradict the cultural homogeneity of the region, the early mythology is nevertheless unified to some extent through being organised according to salt water and fresh water accounts, with some elements linking all. The proliferation of 'creation' versions are not the result of recorder or informant error, but the product of different versions of the 'cultural landscape' itself.

Ngurunderi And Links With The Broader Landscape

The incorporation of new elements from an altered socio-political environment after European colonisation is reflected in recorded Aboriginal mythology. In the Lower Murray, Aboriginal mythology was modified as people embraced Christianity. For instance, Ngurunderi was taken by the Lower Murray people as a suitable interpretation of the concept of 'God' being taught to them by early missionaries (Taplin Journals, 25 June 1859; 22 September 1859). For some contemporary Ngarrindjeri people, this linkage is once again perceived and articulated by them. One young adult told me in 1988 'Ngurunderi is like Jesus. God gave Ngurunderi to the people. God spoke to the people through Ngurunderi.' Several older informants claim that the reason that the graves in the Point McLeay cemetery are arranged with head towards the west is so that the dead person's spirit can go in the direction of Ngurunderi. In the South East region in 1934, a Meintangk Aboriginal man, Alf Watson, claimed that Ngurunderi had warned the Aboriginal people about the coming of Europeans and their destruction of the environment when he said 'Beware of *puruki* (ants)' (Tindale, 1934–1937, vol.2: 57; 1938: 20). The syncretism of tradition is illustrated in an account of Aboriginal people on the Point McLeay Mission in the 1880s who reportedly laid bodies on a Christian-style cross for a short time before being placed on a pre-European-type burial platform.[20] It is clear that a blend of their own practices with new elements has been integral to the constant development of tradition. Old beliefs and customs are made more relevant to contemporary situations through this process.

The Ngurunderi myth complex contains references to areas outside the Lower Murray. Many of these connections may have been made after European settlement, when Aboriginal people from diverse cultural areas were forced into living at the same locations, such as fringe-camps and mission stations. For instance, Taplin noted the belief that two warriors from Ngurunderi's group returned to the Upper Murray, but were never heard of again (1874 [1879: 61]). Furthermore, in the Ngaiawang mythology of the Upper Murray, the two wives of Ngurunderi were said to be the Bakindji sisters involved in the eagle and crow myth epic of the Upper Murray/Darling district (Tindale 1939: 259). In the Mid-Murray region there is mention of Wurranderra—an 'Aboriginal Moses', who reportedly came later than the main creative ancestor, Noreela, to lead forth many northern tribes to the rich waters of the Murray, in the process giving them law and customs.[21] Although Wurranderra is given a secondary creative role in this account, it is

possible that the name is a poor European rendering of the word Ngurunderi. Due to the similarity of this description with that of the Lower Murray ancestor, Ngurunderi, and the likely linguistic similarity, it seems probable that this was an aspect of Mid-Murray mythology given greater prominence by the Lower Murray people. Whether knowledge of the Ngurunderi mythology was widespread in Mid-Murray regions before European colonisation is not known. It is possible that Aboriginal people there incorporated this Ngurunderi-type account during historic times on the basis of having heard it from Lower Murray people they had met.

According to Taplin's informants two other young men from Ngurunderi's group had taken a party south along the Coorong, establishing themselves in the Lower South East near Mount Gambier (Taplin 1874 [1879: 62]). Another version, obtained from Alf Watson by Tindale in 1934, acknowledged Ngurunderi and his two nephews as 'creators' for areas inland from Kingston, involving places such as Mount Benson and Cape Jaffa (Tindale 1934–1937, vol.2: 58–60). All these places are outside the Lower Murray cultural region. Therefore, although particular episodes of the Ngurunderi myth, as told by the Lower Murray people, were chiefly confined to their own territories, this mythology did provide links to other cultural regions. In the last half of the nineteenth century, the large ceremonial gatherings where initiations were held involved Aboriginal people from throughout the Lower Murray, as well as people from places outside the cultural region, such as from Murrundi (Moorunde) on the Murray River, and the Rufus and Darling River area (Taplin Journals, 24 November 1859; 12 May 1860; 6–10 & 27 August 1860; 17 March 1862). The last recorded initiation sequence of ceremonies which included Lower Murray people took place from 1879 to 1882 at Matanga (Metang) south of Mannum, and involved people from the Victorian and New South Wales part of the Murray River, as far away as the Darling River Junction at Wentworth (Berndt & Berndt 1993: 166, 167). At these large heterogenous gatherings, revised explanations of the cosmos could have been achieved to make the pre-existing mythology more relevant to all regions.

Some recorded versions of myth reveal innovations which, because of their wide areal coverage across major cultural divisions, suggest post-European origins. A version of the Ngurunderi epic recorded in 1936 from Clarence Long, a Tangani-speaker from the Coorong, involves range of localities from Mount Gambier in the lower South East to the Adelaide district.[22] In this example one of Ngurunderi's sons travelled south and was chased by a 'big devil' named Mirka, who emerged from the Blue Lake. The son fled north along the Coorong and across the Mount Lofty Ranges to Willunga, forty kilometres south of Adelaide. Ngurunderi, who saw them approach, attacked and wounded Mirka at Red Ochre Cove.[23] The congealing blood of the 'devil' formed a rich red ochre deposit at this place, now part of an Adelaide outer suburb. Mirka fled back to the Mount Gambier district, his dripping blood creating other ochre outcrops.

The existence of this broader account is probably best explained in terms of post-colonial Aboriginal people gaining extensive geographical knowledge through participation in early agricultural activities throughout the colony, such as shearing and harvesting.When Aboriginal people from the Lower Murray region encountered mythologies concerning a different landscape, it is likely that they drew close comparisons with their own creation beliefs. Through this process, Ngurunderi may have assumed the identity of mythical ancestors in new areas. The possession by Aboriginal people of knowledge concerning key points in the landscape, however short the experience with them, imparts a sense of authority over their environment. Mythological sites, as 'places', reflect both the political and social dimensions of the relationship Aboriginal people have with the landscape.

In 1935 Tindale recorded an unpublished version of Ngurunderi from an Aboriginal man named Spender, who had descent connections to both the Adelaide and Lower Murray regions. In his journal, Tindale wrote:

> Ngurunderi came from east to Cape Jervis; he chased his two wives who were sisters; they swam towards Kangaroo Island; he killed them and turned them into the Sisters islands (the Pages). Ngurunderi landed on Kangaroo Island beside a sheoak tree. He went to the western end of the island and threw his spear out into the water. It made some islands there (he [Spender] had only heard about them). Ngurunderi then crossed the sea, manner not defined, and came to Corny Point. From Corny Point he entered the sea and swam to "Cotton Island" which is off Tumby Bay. He landed on the island and, at low tide, walked over the shallows to the mainland. He changed his name (name forgotten [by Spender]) and travelled to the west (Tindale 1935 MS: 45).

This version links several distinct cultural regions across southern South Australia.

Another example of adaptation was provided by Lola Cameron-Bonney, who defined herself as a Coorong Aboriginal person with family connections to western Victoria, and by Ronald Bonney, who had links from the Lower Murray to the South East and Victorian regions.[24] They gave a variation of the Ngurunderi epic that appears to have been influenced by the New Testament. In this version, Ngurunderi travelled to an Aboriginal camp in western Victoria and found that people there were starving. He left, returning half a day later with fish and bread for the camp. The fish were of a type not found there. From here, Ngurunderi then went back into South Australia. Accounts such as these indicate that Aboriginal people often make links, through the 'discovery' of myth, between their own cultural area and the new places they find themselves, as part of extending their 'cultural landscape'.

For most of this century knowledge of Ngurunderi within the Aboriginal community was retained almost exclusively by a few elderly people who still had some understanding of pre-European beliefs and customs. It was part of what has been defined as 'memory culture' (Berndt 1974: 22, 25; Tonkinson in Berndt & Berndt 1993: xix). Portrayals of Aboriginal mythology in the popular literature have helped keep Ngurunderi at the forefront of public knowledge of Aboriginal beliefs concerning the 'Dreaming'.[25] During the early 1980s much site-related information could still be gathered concerning historic Aboriginal sites, but not so with the creation myth information, as it had increasingly become less relevant to Aboriginal people who were experiencing the landscape in new ways (Clarke 1994, Chapter 7). Many localities of previous mythological significance were no longer visited by Aboriginal people, who increasingly lived at missions, working-class urban areas of Adelaide, and fringe-camps, from the early twentieth century to the 1960s. The emergence of Point McLeay (or Raukkan as Aboriginal people call it) as a 'place' that connected all Ngarrindjeri people through a shared mission history became a key element of Aboriginal identity in Lower Murray.

The Ngurunderi mythology was rejuvenated in the late 1980s, partly through the South Australian Museum adopting this mythology as the basis of its Lower Murray cultural exhibition, and also through the coverage which the Education Department of South Australia gave it in its Aboriginal studies curriculum (Hemming 1988; Hemming & Jones 1989; Education Department 1990; 1991). The video, 'Ngurunderi: a Ngarrindjeri Dreaming', was produced as an introduction to the Ngurunderi exhibition in the South Australian Museum.[26] This relatively recent activity has had a major impact upon the portrayal of Lower Murray culture. The modern promotion of Ngurunderi has therefore gained much impetus from forces external to the Aboriginal community. With the increasing voice that Aboriginal people are having in heritage issues, coupled with a renewed focus by them on the past culture, Ngurunderi is once again a prominent figure, albeit a standardised one from the many accounts available.

Dreaming As Reality

As a number of researchers have pointed out, myth is defined by Western tradition in two main contradictory ways (Kirk 1973: 8; Berndt & Berndt 1989: 1). Myth is firstly construed as an invented or fictitious story. In this sense, myth is a false and trivial belief. This definition is often used by those, possessing the ideology of a dominant culture, who seek to define what they consider to be the 'superstitions' of historically subordinate cultures. The second concept of myth describes it as a 'traditional' belief or a reflection of a culture, and allows for less emphasis on evaluating its true/false aspects. As an expression of a culture myth has been well explored by social science. Durkheim (1915) considered myth as one of the essential elements of religious life, representing the way in which society portrays humanity and the world. Malinowski (1948) developed this further, seeing the prime function of myth to be the recording and validating of cultural institutions. Kirk has pointed out that a problem with these interpretations is that not all myths are closely associated with ritual or religious practices (1973: 11, 12). Some myths appear quite secular although they still reflect deeply rooted cultural values.

Although Aboriginal myth provides explanations of the world, the analogy of Aboriginal myth with a European notion of history as a systematic and linear record of past events is confusing. The Aboriginal English use of 'history' to mean the 'Dreaming' in some regions of Australia provides non-Aboriginal people a further source of misunderstanding. Myth can, in some contexts, be regarded as an Aboriginal version of history, but it is much more. Levi-Strauss (1966; 1977; 1978) considered all myths, when correctly understood, to be speculative, or problem

reflecting. He recognised that myth provided a view of the world that can be constantly explored and modified by culture. It follows that a particular myth can mean different things to different people, with many equally valid versions. Many myths have varying layers of meaning (Berndt & Berndt 1989: 3). They are not static constructs that withstand empirical testing, but, as the Lower Murray evidence suggests, are able to incorporate new elements with ease. Baker maintains that the Dreaming 'straddles European distinctions between politics and religion' (1989: 110). Following Hiatt (1975) and Sutton (1988), I argue that history, as it is perceived by Western Europeans, and Dreaming mythology as perceived by Australian Aboriginal people, may have similar functions in their respective cultures, but are nevertheless not synonymous.

The "places" highlighted in the myths are tangible points that linked people with the Dreaming. These focal points in the mythic landscape helped provide Aboriginal people with a local identity. Berndt claims that "there is no religion without sites or without a concept of "landedness" (1970: 53). As the nature of the cultural relationship with the land changed, such as through European intrusion, new sequences of myth were "discovered" or developed so as to validate it. Geographic information concerning other parts of southern Australia were appropriated by myth-makers. Ngurunderi's tracks coincided with the spread of Ngarrindjeri people across the land. When Aboriginal movement patterns became more restricted by government agencies in the early twentieth century, Aboriginal cultural identity became more closely aligned to mission and fringe-camp sites. Both myth and tradition adapted to fit new cultural landscapes.

Conclusion

The variation described for the Lower Murray mythology does not represent the poor recording of a standard account. Rather, as a whole it represents a symbolic text through which differing relationships that people have with the landscape are articulated. In the early years of European settlement, there were many distinctive accounts of Ngurunderi throughout the Lower Murray region, reflecting its importance in explaining the country. Thus the myths reflect the existence of differing perceptions of the cultural landscape itself. The perceptual world reflects the perceived relationships between people. Places featured in the mythology are tangible elements which help give authority to particular world views. Aboriginal people, like other cultural groups, draw meaning from the landscape.

Through the partial collapse of pre-European systems, the spread of Lower Murray people in southern South Australia resulted in the Ngurunderi mythology becoming significant for a much broader landscape. When these people moved outside their region, the feats of the different ancestors they encountered when socialising with other groups were sometimes reassigned to Ngurunderi. As a dynamic record of the past, in relation to the present, the Ngurunderi myth complex has been a vehicle for Aboriginal people to investigate and restate their own identity. Today, this spirit ancestor remains as a symbol of the Lower Murray as a cultural region. This myth is symbolic of a regaining of the past, albeit through the agency of museum displays and videos rather than through the earlier context of ceremonial gatherings at particular important sites. The construction of mythology has not been restricted to a time long before European invasion, but has existed as a continuing process of the development of tradition up until the present.

Acknowledgments

This paper is based on material in the author's Ph.D thesis, which was supervised by Chris Anderson, Peter Smailes and Kingsley Garbett. Drafts of this article were commented on by Peter Sutton, Tom Gara, and Philip Jones.

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Endnotes

[1] Smallpox was introduced into Australia on several occasions, probably initially in the north by Malays (Cleland 1966: 155, 156). One outbreak reached Port Jackson in 1789. The occurrence of the disease in the Lower Murray in about 1830 was part of a later wave. See accounts provided by Teichelmann & Schurmann (1840, pt 2: 34) and Gell (1842 [1904: 99]) for the Adelaide region, and by Hahn (1838–1839 [1964: 129]) for Hahndorf, Mount Lofty Ranges area. In the Lower Murray and the South East regions, the disease is documented by Angas (1847a: 123), Taplin (1879: 45), Taplin (Journals, 25 June 1861), McCourt & Mincham (1977: 68, 69; 1987: 148), and Jenkin (1979: 28–30). Similar records exist for the Darling area (Newland 1889: 1) and for Victoria (Dawson 1881: 60; Bulmer 1887: 31). Stirling (1911), Berndt (1989: 64), and Berndt & Berndt (1993: 292) comment on the timing of these waves.

[2] Taplin (1874 [1879]; 1879) uses the term 'Narrinyeri' (= Ngarrindjeri). See Darwin (1890), Ratzel (1896), and Durkheim (1915) as examples of scholarly interest in 'primitive' Aboriginal culture from the Lower Murray region.

[3] For accounts of the distinct separation of ceremonial knowledge between the sexes in Central Australia see Bell (1983: 182–228), and Payne (1989: 47–49). These authors refute that either gender possessed 'inferior' sacred knowledge – just that they were somewhat different and expressed within their own realms.

[4] Hercus (1989: 105, 106), Jacobs (1989: 90) blames an

external system controlled by non-Aboriginal people for having constructed a lesser role for women in land-related issues in relatively recent times.

[5] The same variation is found in other parts of Australia, such as Arnhem Land (Berndt & Berndt 1989: 389–407).

[6] Nurelli has also been recorded as Noreele (Eyre, 1845, vol.2: 356). Berndt (1974: 27) equates Nurelli from the Mid-Murray with Nepeli of the Lower Murray. Korna (= Corna) was a creation being recorded by Penney from the Encounter Bay region (Clarke 1991b: 96–98). Thukabi was an ancestral turtle who created the river and lakes when leaving the land for the sea (Clarke 1994: 114).

[7] Peterson (1976) summarises the 'tribe' debate. Berndt (1959) provides a critique of the application of 'tribe' theory in the Western Desert region.

[8] Many recorders of the name Ngurunderi, apparently did not hear the initial 'Ng'. For example, he is recorded as 'Runderudie' (*Register*, 1 June 1885) and 'Narrundi' (*Register*, 21 June 1909). It is also possible that the 'Ng' is a later introduction. In 1894, an Aboriginal man, Jacob Harris, spelled Ngurunderi as 'Noorondourrie' (J. Harris letters, D6510(L)13, Mortlock Library, Adelaide). Similarly, Parker (1936) recorded this as 'Nar-oong-owie'. Nevertheless, Ngurunderi is the standard orthography now in general use (Berndt 1940; Tindale 1974: 64, 133; Hemming 1988; Hemming & Jones 1989; Education Department of South Australia 1990; Berndt & Berndt 1993). Unless the rendering of Ngurunderi is greatly altered by the sources cited, I will use Ngurunderi as the standard term.

[9] See Meyer (1846 [1879: 205, 296]), and Tindale (1934–37: 51, 293, 294; 1930–32: 102–105, 117–121) for Encounter Bay interpretations of the Ngurunderi mythology. Accounts by G. Taplin (*Register*, 30 January 1862; 1874 [1879: 55–62]; 1879: 38, 39), F. Taplin (*Register*, 24 April 1889), Ramsay Smith (1930: 17, 173, 182–184, 216, 250, 317–331), Tindale (1934–37: 284–292, 295, 296; 1930–52: 120), and Berndt (1940) are concerned more with the inland areas of the Lower Murray. Versions of Ngurunderi from the Coorong/South East region are recorded by Tindale (1931–34: 182, 183, 185; 1934–37: 30–37, 57–60). An unlocalised version appeared in the *Register*, 2 December 1893. Generalised treatments of this myth are given by Tindale & Pretty (1980: 48–50), Hemming (1988), and Hemming & Jones (1989).

[10] This version is given by R. Penney (as 'Cuique') (*South Australian Magazine*, November 1843, vol.2: 331–336). Cawthorne (1844 [1926: 25, 26]), and Gill (1909: 98, 99) cite Penney without reference.

[11] Account from the 'Herald of Kapunda', in the *Register*, 4 September 1872.

[12] In a photograph taken by Ransay Smith (c.1920), these rocks are shown to be the two largest boulders in the shallow water near the site of the Bluff Whaling Station (AA263, Acc.no: 2126, AP2971, Anthropology Archives, S.A. Museum).

[13] Taplin (1874 [1879: 55–62]). The Taplin Journals (18 December 1861, 10 November 1862) have an outline of the Ngurunderi epic involving 'Noorunderee' and 'Neppelle' chasing a 'giant fish' off from Tipping (Point Sturt). The standard spelling of 'Nepeli' and 'Waiyungari' used here is taken from Berndt & Berndt (1993).

[14] Tindale (1930–52: 188–191; 1935) recorded the feats of Waiyungari and Nepeli from a Yaraldi-speaker named Frank Blackmoor. Other versions are given by G. Taplin (*Register*, 30 January 1862; 1879, p.56). F. Taplin (*Register*, 24 April 1889), and Berndt & Berndt (1993: 228–230). A similar account by Laurie (1917, citing Hackett) appears to have in error replaced 'Nepeli' with 'Nurundie'. The original manuscript (in a notebook titled 'Narrung Alpha', August 1915—personal collection of L. Padman) from which Laurie probably copied his version refers only to a 'mighty man', with no reference to 'Nurundie'. Meyer (1846 [1879: 201, 202]) gives a related version that has 'Pungngane' instead of Nepeli.

[15] Bonwick (1870: 204). The account of the wives attempting to elope with someone else bears more relation to the Waiyungari account, than that of Ngurunderi (see endnote 14). The description of the main characters as 'dragons' appears to be a poetic introduction by Bonwick.

[16] Berndt (1940), and Berndt et al (1993: 13–16, 229–223, 433–441). Tindale's work with Karloan remains largely unpublished (Tindale, 1934–37, vol.3: 284–292, 295, 296).

[17] The inclusion of Blackford was probably a recent introduction. Blackford is a farming property where several Aboriginal families in the South East region have lived. It is now managed by the Aboriginal Lands Trust, and leased out by local Aboriginal people.

[18] Before Aboriginal people were able to perceive Kangaroo Island as an isolated land mass, it is likely that this place itself represented the 'Land of the West' where souls go. Its role as a stepping stone to the Sky World is possibly a modification brought about by Aboriginal experience commencing during the occupation of the island by European sealers during the early nineteenth century. One of the Ngarrindjeri names for this previously uninhabited island was 'Ngurungaui', reportedly meaning the dead spirit 'is departing to travel along the track of Ngurunderi' (Berndt 1940: 181).

[19] Tindale published the 'Story of Ngurunderi' in the *Advertiser*, 16 May 1936. His main Coorong informant used in this account was Clarence Long (Tindale 1931–34: 182, 183, 185; 1934–37: 30–36, 223). Tindale & Pretty (1980: 48–50) give an outline of the composite account earlier developed by Tindale.

[20] *Register*, 1 June 1885.

[21] Bellchambers (1931: 112, 125) recorded the Noreela myth from a Mid-Murray Aboriginal man named Natone (Nettoon). Although Noreela is female, there appears to be a close linguistic similarity of the name with the male spirit, Nurelli.

[22] Tindale (1981–34: 182, 183, 185; *Advertiser*, 16 May 1936). See discussion of this myth by Clarke (1991a: 68).

[23] The importance of Red Ochre Cove, in the post-contact situation, is indicated by the record of Lower Murray people from Point McLeay Mission, travelling to Noarlunga to obtain initiation ochre in 1860 (Taplin Journals, 12 September 1861). Tindale calls this place Putawatang (Tindale, 1934–37: 154). Berndt & Berndt (1993: 20, 23, 117, 129, 234, 312, 446) record this site as Mulgali or Putatang.

[24] Account received during South East fieldwork by S. Hemming and P. Clarke in the mid to late 1980s.

[25] Ramsay Smith (1930: 182–184, 317–331), Parker (1936), Mountford & Roberts (1969: 20–25; 1971: 34, 35), and Reed (1980: 64–72).

[26] 'Ngurunderi: a Ngarrindjeri Dreaming' was produced by the South Australian Film Corporation and the South Australian Museum. It has appeared several times on national television. Hemming (1988) discusses the making of this video.

OBITUARY

NORMAN B. TINDALE

12 October 1900 – 19 November 1993

In 1967 at the age of sixty-six, and after a professional career of forty-nine years spent in the service of the South Australian Museum, Norman Barnett Tindale received an honorary doctorate from the University of Colorado. Among the voluminous manuscripts bequeathed by Tindale to the South Australian Museum is a collection of thirty-nine letters written by colleagues and peers from around the world in support of this award. As more than one letter observed, that such an award was being contemplated by an American university did not reflect well upon the lack of initiative of Australian institutions in this respect. Tindale was eventually honoured with a doctorate by the Australian National University in 1980. But none of those letter writers, assessing the contribution of an anthropologist and scientist in the twilight of his career, could have predicted that Tindale would continue to publish and undertake research for another quarter of a century.

Tindale was an early starter as well as a late finisher. He had already published thirty-one papers on entomological, ornithological and anthropological subjects before receiving his Bachelor of Science degree at the University of Adelaide in March 1933. These papers joined a further 100 papers published during his employment at the South Australian Museum, an average output of three papers each year, mostly published in refereed journals. In this sense he was an outstanding product of the British institutional science tradition—trained on the job, self-educated and judged by scientific contributions rather than degrees. That the Australian expression of this tradition also reflected a perennially meagre budget commitment to science on the part of state governments and a general lack of public support in most intellectual areas may have been apparent to Tindale, but was rarely dwelt upon. There was work to do.

Tindale was born in Perth on 12 October, 1900, the eldest of four children. His parents were committed members of the Salvation Army and in 1907 the family travelled to Tokyo, Japan, where his father took up a position as an accountant with the Salvation Army mission operating in China. Tindale's personal and professional life was marked by turning points; this was the first. He grew up with a good knowledge of German and French, as for several years these were the only languages taught in the small private school which he attended with the children of diplomats. One of Tindale's close school friends was Gordon

Bowles, later to become Professor of Anthropology at Syracuse University as well as a colleague in wartime Intelligence work. But Tindale spent most time with the children of Japanese neighbours, speaking street Japanese, playing in the semi-rural suburbs of Tokyo (still a largely feudal city), and exploring the countryside nearby. It was these rambles, and resultant trips to Tokyo's Imperial Museum, which introduced Tindale to the world of natural history and to entomology in particular. Through the Museum, his father's library, and his own experience of Japanese customs, Tindale gained a taste for anthropology.

But by the time that the Tindales left Japan during August 1915 to settle first in Perth and by February 1917, in Adelaide, Norman had no doubt that he would pursue a career as a natural scientist. Butterfly and moth collecting had become his passion and he explored the possibility of gaining a job at the South Australian Museum. Aware of a possible impending vacancy there, he took up a position as a library cadet at the Adelaide Public Library in May 1917 working alongside another young cadet, the future nuclear scientist Mark Oliphant. More than thirty years later, Tindale encountered Oliphant again, in the Top Secret area of the Washington's Pentagon, emerging from a section labelled 'Manhattan Project'.

A few months after taking up his cadet's position Tindale lost the sight of one eye in an acetylene gas explosion while assisting his father with 'limelight' photographic work. The accident dulled none of Tindale's enthusiasm or ambition. Just before the explosion he had begun to read Alfred Wallace's 'Travels on the Amazon and Rio Negro'; a few days after the explosion he took it up once more and wrote in his diary: 'My mind seems made up about following such a life as his. I hope to take him as my model' (Tindale ms.). In January 1919 he finally secured a Museum position as Entomologist's Assistant under the mercurial Arthur M. Lea. He later recalled that Lea told him, 'Tindale, you'll never make a blind entomologist, but you might make a blind anthropologist!'. Both seemed possible to the young scientist.

The next turning point in Tindale's career came when he received permission in 1921 to undertake an extended field trip to Groote Eylandt in the Gulf of Carpentaria. The opportunity arose through Tindale's family background in missionary activity. This had brought him into contact with the Church Missionary Society of Australia and Tasmania, which was extending its mission work from a base at Roper River to Groote Eylandt. Tindale was engaged by the Society for twelve months to assist in the establishment of a home on Groote Eylandt for half-caste children from the mainland. He was to be given time to collect for the South Australian Museum which would purchase his specimens at the completion of the trip. At this stage no Aboriginal objects from the island were preserved in any museum. Tindale's Director, Edgar Waite, recognised the ethnographic potential of the expedition and directed the young entomologist to visit the doyen of Australian anthropologists, Baldwin Spencer, at Melbourne's National Museum, for advice. Spencer's advice was simple; to follow the directions for field observation laid out in 'Notes and Queries in Anthropology' (he gave Tindale his own copy) and to keep a field journal with a daily record under every circumstance, even if the following day's events invalidated a previous entry. Spencer also introduced Tindale to the Geographic I method of language transcription, the basis for Tindale's unique collection of more than 150 parallel vocabularies across Aboriginal Australia.

Tindale followed Spencer's advice to the letter and gathered a remarkable collection of ethnographic data and more than 500 artefacts from Groote Eylandt and Roper River during his twelve months in the field. This was the longest period to that date spent by a scientist in the company of Aboriginal people. During that expedition Tindale's main informant, a Ngandi man named Maroadunei, introduced the young scientist to the concept of bounded tribal territories, 'beyond which it was dangerous to move without adequate recognition' (Tindale 1974: 3). Yet Tindale went to Groote Eylandt and the Roper as a naturalist, and returned as one. The crucial shift in his career took place well after his return to Adelaide, when his synthesis of anthropological data for publication made him aware of the openings and challenges which the new field offered. In particular, when Edgar Waite insisted that Tindale remove tribal boundaries from a map of Groote Eylandt and the adjacent mainland being prepared for publication in the Museum's Records, maintaining that nomadic Aborigines could not occupy defined territories, Tindale realised that a new paradigm in ways of regarding and describing Aboriginal Australia was sorely needed.

The Groote Eylandt expedition revealed Tindale's remarkable appetite for fieldwork.

Taken together, his dozens of field trips amounted to more than seven years of his professional career spent in the field, an average ratio of nearly two months of every year. A colleague later observed that Tindale was never quite himself back at the office, and it required very little to entice him out once more. But it was in the field, exposed to the nuances and implications of the natural and cultural environment which he regarded as the unrestricted object of his study, that Tindale came into his own. His broad-based training enabled him to undertake this task confidently and to weave together the diverse strands of natural and human science. Trained in geology (a Pleistocene Stratigraphy course at the University of Adelaide) under Douglas Mawson, geography under Grenfell Price and heavily influenced by the publications of Wallace, it was axiomatic that Tindale would adopt a strongly ecological approach to his field observation and collecting. This approach was greatly reinforced by his contact with Aboriginal people for whom the distribution and habits of plant and animal species were crucial data. Tindale's bibliography reflects this great diversity of interest and its complementary character, particularly in the case of his geological papers which overlap with those discussing Pleistocene archaeology, or his entomological or botanical papers which overlap with interests in linguistics or material culture.

Looking back on Tindale's career it is possible to discern half a dozen research paths which he followed, converging and diverging but persisting across several decades until his death. Few specialists would attempt to emulate such a course today; in Tindale's time, as his colleague and friend Joseph Birdsell put it later, it represented the 'proper breadth of interest'.[1] In entomology, his first love, Tindale selected the study of the Hepialidae, one of the most primitive of the moth families; in geology his particular interest became the study of Pleistocene shore-lines and Tindale was to become recognised as one of the 'foremost workers on the Pleistocene geology of Australia' (Daily 1966). In linguistics as in broader anthropological studies his object was to gather sufficient data to scientifically describe variation in Aboriginal culture and society across the country. The same applied to his physical anthropological surveys. More focused studies, such as an investigation of initiation practice, Western Desert art and mythology, or the detailed description of a coastal and riverine society, followed from this survey data. In archaeology, informed by his geological and ecological training, Tindale's object was to establish the broad canvas on which more specific applied or theoretical investigations could be painted. Tindale's field trips became the testing ground for this tumult of ideas and theories against a background of wide reading in each area and constant rapport with colleagues, nationally and internationally.

The tracks connecting these paths were often of equal interest. For example, Tindale's interest in the primitive Hepialidae led him into the palaeontological field, linking with his geological and anthropological interests. He eventually discovered and described *Eoses*, considered to be the most ancient fossil lepidopteran (of Triassic age), through a careful examination of the Mt Crosby fossil beds in Queensland. So much for a blind entomologist. Likewise, Tindale's expertise in the Lepidoptera field brought him into contact with scientists and administrators charged with eradicating or controlling insect pests, and with the issue of satisfactorily managing Australia's national parks. Tindale was appointed in 1958 as a member of the national Committee on National Parks and Reserves of the Australian Academy of Science and made active contributions to the growing debate about conservation issues. His input to South Australian legislation on National Parks, enacted during 1966, was also considerable. Through such connections he also became a founding member of South Australia's National Trust committee. As chairman of the Trust's Nature Preservation Committee, Tindale could take much credit for the preservation of the internationally known glacial pavements at Hallett Cove. He was able to doubly underline their significance through his geological expertise with ancient shorelines and through his careful documentation of the massive 'Kartan' Aboriginal stone tools associated with this particular locality.

Tindale's life was full of such connections. The most striking, yet least known, was the use which he made of his intimate knowledge of the Japanese language. At the outbreak of the Second World War Tindale's attempt to enlist in the Australian army was thwarted by his damaged eyesight. With Japan's later entry into the war his value to military intelligence operations was soon recognised; he and his brothers, together with his old friend Gordon Bowles, were among the few

[1] This phrase forms the title for the Masters thesis written by Tindale's grand-daughter Karen Walter, dealing with Tindale's early career (Walter 1988). I am grateful to her for the opportunity to use data contained in this thesis for this survey of Tindale's life.

Australians fluent in Japanese. During 1942 Tindale joined the R.A.A.F. and was assigned the rank of Wing Commander in England before being transferred to the Pentagon to advise on strategic bombing. There he headed the military intelligence unit charged with deciphering Japan's military codes and with ascertaining the origin and volume of production of munitions and spare parts. Tindale and his small unit spent time combing through the wreckage of crashed Japanese aircraft. They intensively analysed this debris in a laboratory established at his initiative near Brisbane. Through metallurgical and serial number analysis and by deciphering the company marks found on different components Tindale obtained remarkably accurate data on production figures and Japanese shortages of critical alloys. Professor W. V. MacFarlane later wrote: 'this somewhat esoteric complex of knowledge of language, ability to associate minute and apparently unrelated fragments of information to induce patterns of understanding, and to deduce consequences, has been characteristic of his work amongst Aboriginals from every part of the continent and its surrounding islands' (MacFarlane 1966).

Tindale eventually achieved two breakthroughs which altered the course of the war in the Pacific. Both are still unknown to the wider public. He was instrumental in cracking the Japanese aircraft production code system, which gave the Allies reliable information as to Japanese air power. More importantly, he and his unit deciphered the Japanese master naval code. Another commander in U.S. military intelligence later wrote that the success of the attack 'upon the homeland of Japan was more effectively measured through the work of Tindale and his group than through any other source of intelligence we had available at the time' (Brown 1966). This fact was established through the Strategic Bombing survey undertaken in Japan after the war.

Just as extraordinary was Tindale's application of his special skills of detection in halting the only enemy attack on the continental United States—the fire-bombing of the Pacific North-West which occurred for a twelve-month period during the war. The attacks caused many forest fires and killed several civilians. Tindale examined the shattered remains of the balloon carriages which transported these bombs from Japan and established not only the rate of their production, but their points of manufacture and release. With this information those sites were bombed and destroyed, ending this form of attack.

Tindale was reluctant to talk about this momentous phase in his career, believing himself, even as late as 1989, to be bound by the wartime British Official Secrets Act. He continued his practice of keeping a daily journal throughout the war period but restricted his observations to natural history and anthropology. He found time to record anthropological detail and collect artefacts during his 'special duties' in New Guinea and the Solomon Islands. During spare moments in America he studied and reorganised the Australian osteological collection at the Smithsonian Institution and even discovered a new species of Lepidoptera (*Sthenopis darwinii*) in Tennessee.

Tindale's entomological career may have been overshadowed by his anthropological achievements but he never lost contact with this first love. This was so in a direct sense; his desk invariably contained a jar of insects or an open file on the subject. On field trips his days usually ended with an examination of the evening's haul of moths and insects caught in his portable light-trap. The same routine was observed, particularly during summer months, at his Blackwood home, overlooking the lights of Adelaide. Both in Adelaide and in retirement in Palo Alto he made his own carefully chamfered wooden boxes for Lepidoptera specimens. But Tindale's entomology did not simply consist of collection and description. As with his anthropological studies, he became interested not only in questions of geographical variation but in origins and early stages, as well as in specific issues of ecology.

Tindale had begun collecting and classifying butterflies in Japan at the age of ten. His professional entomological studies began during his Groote Eylandt expedition of 1921–22. Concentrating upon the Lepidoptera and the Orthoptera on his return, Tindale undertook revisions during the later 1920s of the Australian Mantidae (mantids) and Gryllotalpidae (mole crickets), regarded for decades afterwards as standard works in this field. But it was his interest in the more primitive Lepidoptera, specifically the Hepialidae, which established Tindale's long-standing international reputation as an entomologist. I. F. B. Common observed that Tindale's revision of the Hepialidae family 'represented a new critical phase in the study of Australian Lepidoptera' (Common 1966). Until the Second World War it was the only major revision of the fauna which had taken the male genitalia into account, and thereafter placed the classification of the Hepialidae on a firm footing.

This detailed revision, published in several papers over a period of thirty-two years from 1932 to 1964, provided the basis for ecological studies leading to more effective control of several *Oncopera* species, for example, which are serious pests of high-yielding sown pastures.

Tindale became a world authority on the hepialid moths, a notable achievement considering the difficulties which they present to researchers. In acknowledging this, H. K. Clench of the Carnegie Museum observed that the moths are often rare, and with brief flight periods, difficult to collect in adequate numbers for study; their characters are cryptic and, because of their ancient origins, their distribution poses additional problems for the investigator who requires an intimate knowledge of them across their entire world distribution (Clench 1966). Patiently amassing material and data over several decades, visiting museums throughout the world and collecting in as many regions and environments as possible, Tindale acquired this knowledge and earned the respect of his entomological colleagues. He discovered and described many geographical races of moths, some species, and many life histories, carefully analysing the events which he considered were responsible for each situation. In John Calaby's words, his entomological studies became 'much more than mere descriptions of animals' (Calaby 1966). His attention to the evolutionary implications of his data was of great importance to the much broader fields such as speciation patterns and the general evolutionary history of the Australian fauna as a whole.

As noted, Tindale's entomological work often connected with his anthropological studies. His interest in the Hepialidae and Cossidae was particularly apposite here, since many of them have wood-boring larvae used as food by Aborigines. Several of his papers addressed this subject, providing a vivid example of his attention to the ecological contexts which sustained human and animal life throughout Australia. Already inclined to an ecological approach, Tindale was given great encouragement through his association with the University of Adelaide-based Board for Anthropological Research, and in particular its chairman, J. B. Cleland. The Board undertook annual expeditions during the university's August vacations of the late 1920s and the 1930s with the primary object of recording series of physiological and sociological data relating to Aboriginal groups which had experienced little sustained contact with Europeans. Cleland ensured that these data were recorded within an ecological frame, encouraging Board members to note aspects of geology, flora and fauna. Tindale applied this general approach to the study of Aboriginal territoriality, relating particular groups to specific environments through a range of careful observation, backed up by ethnographic and archaeological evidence. He developed this approach thirty-five years before territoriality and ecology (or even Australian anthropology itself) became voguish fields.

As the Board expeditions progressed during the 1930s Tindale began to correlate his data in ways which few anthropologists had previously done. He collected and documented artefacts with a strong awareness of how their manufacture reflected necessities dictated by the environment and opportunities to manipulate or exploit that environment. Over the years the careful accumulation of such detail resulted in important papers on material culture and the Australian environment, such as his 1976 publication on the *Panara* or seed-milling technology of the Central Australian grasslands. During the 1930s he paid particular attention to the documentation of social, as well as technological, processes, and was encouraged by other Board members to master the arts of sound and film recording. Tindale first attempted ethnographic film-making during his expedition with Herbert Hale to Queensland's Princess Charlotte Bay in 1926–27. Films made at Hermannsburg (1929), MacDonald Downs (1930), Cockatoo Creek (1931), Mt Liebig (1932), Mann Range (1933), the Diamantina south of Birdsville (1934, assisted by H.K. Fry) and Warburton Range (1935, assisting Stocker) followed. Of these, his Mann Range sequence, four reels comprising 'A Day in the Life of the Pitjandjara [sic]' remains the most compelling. Tindale cleverly edited sequence from dramatic footage shot over a period of several weeks to construct a 'typical' day in the nomadic existence of the Pitjantjatjara as they travelled from water to water through the Mann Ranges. Wax cylinder recordings of ceremonies and song cycles were made separately by Tindale on each of these expeditions; in many cases they represent the only surviving record of their kind.

Tindale's concern was not to preserve an account of culture for its own sake, but to document in sufficient detail to enable further analysis by others. 'Making a useful record' was a phrase he often used, applying it equally to his compilation of 150 parallel vocabularies as to his descriptions of manufacture and use of spears, spear-throwers, dishes, stone tools, resin, hair

string, and other essential items of desert life. An artefact could be collected, together with examples of raw materials used in its manufacture, and the process could be filmed. All processes and observations and linguistic terms were recorded meticulously in note form, together with the genealogies and backgrounds of the makers or participants, from whom further mythological detail could be elicited through crayon drawings on brown paper which he distributed and later carefully annotated.

The sound recordings made by Tindale during the 1930s have still not been properly studied. As with film, he continued to make these vital records of Aboriginal life well into the 1960s, in central and northern Australia. On his return to active fieldwork after the war Tindale adopted reel-to-reel tape recorders instead of the wax cylinder machine and began experimenting with colour film. Willing to adopt any worthwhile advance in technology during his working life, Tindale nevertheless stopped short of the computer age. His voluminous shoe-box card files on Aboriginal place names and language terms and his own indexed journals provided a ready entree into most of his research areas.

Tindale's particular duty during the Board expeditions was to note the identities, social and totemic background and genealogical relationships of Aboriginal people. This responsibility provided him with the structure and discipline required to complete his apprenticeship as an anthropologist. In the first place, it brought him directly into contact with Aboriginal people as individuals on a one to one basis. His calm and straightforward manner, leavened with an easy humour but sharpened by an incisive and enquiring approach, elicited data with a minimum of fuss. Aboriginal people remembered Tindale with respect and affection years after his visits. The genealogical exercise also gave Tindale an appreciation of the kinship network as the generative basis of Aboriginal society, in all its different forms across the continent. But in contrast to the social anthropologists trained in the British tradition who were beginning to graduate under Radcliffe Brown and Elkin during the 1930s, genealogies represented far more to Tindale than 'samples upon which to hang kinship terminology' (Birdsell 1966). In the detail recorded by him, they provided concrete evidence of the relationship between individuals, sites and Dreaming sequences.

Additionally, and with major implications for his later research, Tindale's genealogies enabled him to develop a demographic record of Aboriginal Australia as a whole. As with his ambitious work on documenting tribal boundaries and territories, the continental scale of this undertaking was rarely even considered as a possibility by his contemporaries. Tindale first undertook applied demographic studies through his analysis of the Tasmanian Aboriginal descendants of Bass Strait. Published in 1953, the study remained for many years the best total community demographic study in Australia.

The field of population dynamics was almost unknown within Australia when Tindale undertook his Tasmanian study. He was to make a major contribution to it, particularly through his diachronic analysis of the Bentinck Island Kaiadilt people. In a series of papers Tindale demonstrated the effective isolation for approximately 3 500 years of this self-contained population of about 120 people. Through meticulous use of the genealogical method he documented a pre-contact population crash which reduced the island's population by more than 40%. In collaboration with the serologist Roy T. Simmons, and the micro-evolutionist Joseph Birdsell, Tindale demonstrated that the Bentinck Islanders represented a classic case of founder effect, described by Birdsell as the 'most important remaining portion of the Sewell Wright Effect' (Birdsell 1966). Due to the small numbers in the original emigrant ancestors of the Kaiadilt, their descendants differ from mainland Australian Aborigines in some genetic properties as much as do major racial groups from each other in other parts of the world.

Tindale's awareness of the potential of this field was stimulated through his time in the United States during 1936–1937. Following his award of a 1936 Carnegie Research Fellowship (to be followed by a second in 1959), Tindale spent several months studying Australian ethnographic material and lecturing in Europe and the United States. Apart from meeting Birdsell, who became a lifelong friend, Tindale made other friends and contacts in America to the extent that, following the death of his first wife Dorothy during 1969, he was readily able to adjust to life there. Meetings with the environmentally-oriented anthropologists Alfred Kroeber and Earnest A. Hooton, the serologist Carl Sauer, and the geographer T. Griffith Taylor were especially influential, confirming Tindale's anthropological development along lines increasingly distinct from those promoted by social anthropologists emerging from the University of Sydney. In particular, Tindale's meeting with Kroeber at Berkeley refocused his

commitment to mapping the tribal distribution throughout Australia, in order to provide a firm basis for the study of culture traits. At Harvard Earnest Hooton further supported this approach, seeing the importance of a well-documented distributional template for the anthropometric and serological studies which he proposed as a project to Tindale and his favoured student, Joseph Birdsell. The result of these meetings shifted the course of South Australian, and Australian, anthropology.

Hooton's influence enabled one of the most ambitious anthropological surveys every undertaken in Australia, jointly funded by the University of Adelaide and Harvard University. During an eighteen month period through 1938–39, Tindale led a data-gathering expedition supported by Birdsell and accompanied by their wives as secretaries and research assistants. The team travelled by road to almost every Aboriginal settlement and mission throughout eastern, southern and south-western Australia. The object was to undertake a comprehensive survey of the Aboriginal population in its interaction with the non-Aboriginal population, several generations after first contact had occurred. As on the previous Board expeditions, the pair gathered an immense range of physiological and sociological data, measuring, blood-sampling, photographing and interviewing more than 3 000 individuals. The project was completed under Birdsell's leadership and with Tindale's active participation during the years 1952–54, when north-western Western Australia and parts of the Northern Territory were surveyed and some earlier ground retraced, resulting in the survey of a further 2 000 individuals. For Tindale and Birdsell, the 1938–39 expedition represented the beginning of a firm friendship and a working partnership which spanned the next half-century.

The photographic and genealogical records was also to serve another, unforeseen purpose, making Tindale's name familiar to many thousands of Aboriginal people across the country decades later. The establishment of the Aboriginal Family History Project at the South Australian Museum during the 1980s made these records accessible to the descendants of those contacted by Tindale and Birdsell during the 1938–39 and 1952–54 expeditions. Tindale lived long enough to appreciate the impact which this historical record was to make upon the lives of Aboriginal people.

Birdsell's detailed genetic studies of Australian Aborigines (discussed elsewhere in this volume) derived from data first gathered during the 1938–39 expedition. Much of this work was directed towards establishing the thesis, still controversial, that Aborigines had arrived in Australia in three chronologically, and physically, distinct groups. It was Tindale and Birdsell's hypothesis that the first of these groups, ultimately stranded in Tasmania by rising sea levels, were represented on the mainland by the 'negrito' population in the 'ecological refuge zone' of the Queensland rainforest near Cairns. This group was contacted and studied by the pair during the 1938–39 expedition. Tindale furthered his interest in genetics, eventually publishing the first systematic study of gene flow for any simple human population. His 1953 paper in 'Human Biology', based upon his massive genealogical data for the Australian continent, remains a classic.

For Tindale, the 1938–39 expedition enabled him to interview many of the last Aboriginal individuals with knowledge of the group structures and territories of those regions of Australia overtaken by settlement and pastoralism. Combining this primary data with that drawn from manuscripts and secondary sources, he was able to realise his long-standing ambition to prove that Aboriginal groups did relate territorially to distinct regions that could be successfully mapped. His tribal map of Australia, first published in 1940 and revised in 1974 together with his encyclopaedic catalogue of Aboriginal tribal groups, was radical in its fundamental implication that Australia was not *terra nullius*—decades before the Mabo judgement made it a national issue. As importantly, both the 1938–39 and 1952–54 expeditions (the latter accompanied by Tindale only until 1953), resulted in several hundred sheets of genealogical data and more than 6 000 well-documented photographs of Aboriginal people.

If Tindale warmed to any particular Aboriginal group among the hundreds encountered by him during his career it was undoubtedly the Pitjantjatjara. He and the physical anthropologist Cecil Hackett spent almost three months in their company during 1933, observing initiation ceremonies and the minutae of daily life as family groups split and reformed during their travels through the Mann Ranges. Using camels, Hackett, Tindale and their European guide Alan Brumby accompanied the group as 'virtual parasites', making a detailed and unique record of a society on the brink of decisive change. As well as film and sound records, closely documented artefacts and genealogies, Tindale prepared the first detailed vocabulary of the Pitjantjatjara language.

He had further opportunities to learn from these people during field trips to the region during the 1950s and 1960s.

If Tindale warmed to any particular Aboriginal individual during his career it was undoubtedly the Tangane man, Milerum (Clarence Long). Tindale subsequently wrote an entry on Milerum in the 'Australian Dictionary of Biography' (Tindale 1986), detailing the coincidence of Milerum's first contact with Europeans, at the age of six, with Tindale's mother's family, inland from South Australia's Coorong. After 1931 Milerum assisted Tindale by recording a substantial corpus of song in his native Tangane and related languages, and participated in intensive site recording throughout the Coorong and Lakes region. In this Tindale was assisted by the social anthropologist H. K. Fry, who had already given Tindale informal training in anthropological theory. At the time of his death, perhaps Tindale's greatest unfinished work was an ethnographic study of the Coorong region as seen through the eyes of Milerum. Much of this data was gathered during Milerum's extended visits to the South Australian Museum, during which he became a 'resident' artefact maker until his death in 1941.

By the late 1930s Tindale's fieldwork had taken him to every geographic and cultural zone of Aboriginal Australia. His 1921–22 fieldwork in tropical Australia was complemented by a ten week expedition to Flinders Island and Princess Charlotte Bay on Cape York during early 1927 in the company of a museum colleague, Herbert Hale (later Director). Tindale's first, successful experiments with ethnographic film-making occurred during this expedition. He made further expeditions to the tropics during the 1938–39 expedition, and in 1960 and 1963, visiting Mornington and Bentinck Islands and the government settlement at Palm Island. In temperate Australia, Tindale undertook numerous trips to the Coorong, the Lower Murray, the south-east of South Australia and Yorke Peninsula, particularly during the 1930s, and to south-western Western Australia during 1968. His arid zone studies began in late 1924 when he and Herbert Hale worked among the Wailpi and Adnjamathanha people of the Flinders Ranges. This expedition also provided Tindale's first introduction to Aboriginal rock carvings and to the iconography of Central Australia. It also provided a solid basis of comparison for his analyses of rock art of southern South Australia, also undertaken during these early decades. From 1928 Tindale's experience of Central Australia grew rapidly. He was a participant on the Board for Anthropological Research Expeditons to Koonibba (1928), Hermannsburg (1929), MacDonald Downs (1930), Cockatoo Creek (1931), Mt Liebig (1932), Mann Ranges and Ernabella (1933), Diamantina River (1934), and the Warburton Range (1935). During 1934 and 1951 he made individual expeditions to Ooldea. A further Board for Anthropological Research expedition to Yuendumu during 1951 signalled the end of these large, team surveys. Tindale's Central Australian fieldwork was completed with expeditions to the north-west of South Australia in 1957 and 1966, Haast Bluff (also 1957) and the Rawlinson Ranges in Western Australia during 1963.

Tindale's participation in the 1929 Hermannsburg expedition provided him with his first close encounter with desert people and their social system. The eight members of the expedition party travelled on the first train to arrive in Alice Springs from Adelaide and reached Hermannsburg at the height of a scurvy epidemic precipitated by the worst Central Australian drought this century. The medical members of the expedition diagnosed the condition and treated it successfully. Perhaps through this solicitude, and the obvious numerical congruence, each of the eight men was assigned a 'skin' name corresponding to the eight sub-class terms used by the northern Aranda groups. Tindale was given the brown hawk totemic affiliation, *erukalandja*, and was designated as 'Mbitjana' (*Tjampatjimpa*) skin, a classification which he was able to apply to himself in all subsequent dealings with Central Australian Aborigines.

On the day of Tindale's official retirement from the South Australian Museum he set out with his old friend, the American folklorist, amateur archaeologist and accomplished bibliographer John Greenway, on an expedition to Koonalda Cave on the Nullarbor Plain. It was fitting that this expedition, colourfully chronicled by Greenway (1973), had archaeology as its theme. Tindale's career had been characterised by the relentless search for origins which archaeology expresses as a discipline. From the 1920s Tindale's geological studies under Mawson had trained him to interpret the stratigraphy of an archaeological site and he was the first in Australia to use sea-level changes for dating purposes. As Edmund Gill expressed it, Tindale's archaeological work was remarkable for the fact that he studied sites from 'a number of points of view—anthropologic, geologic and palaeologic'

(Gill 1966). This form of analysis at archaeological sites near Adelaide such as Fulham, Pedler's Creek (Moana) and the South Para River had prepared him for his crucial role in Australia's first truly scientific archaeological excavation, undertaken during 1929 at Devon Downs near Swan Reach on the Murray River.

Tindale's emphasis on stratigraphy led him to posit a model of culture succession in Australia, based entirely upon local critieria rather than adopting European models as had been accepted by most other Australian archaeologists. Before Devon Downs, Australian archaeology did not exist as a discipline, largely because it was assumed that Aboriginal people were relatively recent arrivals. Tindale's meticulous excavation established not only that Aboriginal people had lived for several millennia in the Murray valley, but demonstrated that their strategies for subsistence had altered in response to environmental change. He showed how stone tools, animal bones and cultural remains could be used to piece together a previously untold story about Australia's past. His foresight in preserving charcoal samples against the predicted development of C^{14} dating has received scant recognition. Nevertheless, critics of Tindale's construction of an Australian cultural chronology based on his Devon Downs, Tartanga and Noola Rockshelter excavations, together with his classification of the large 'Kartan' implements, acknowledge the precision of his work and the quality of his data.

Tindale's precise work habits, particularly when applied to the documentation of field collections, have ensured that several thousand Aboriginal artefacts, whether archaeological or ethnographic, may be interrogated by future researchers. Struck by the apocryphal anecdote related to him in the British Museum of a worker who had become unhinged and burnt a large number of collection records, Tindale determined that this would never befall his institution. His careful practice of inscribing each artefact with inked locality data was followed for many years. Many of his specimens are also figured and described in his journals over a collecting period of almost half a century.

These journals, Tindale's collected specimens, and the entire range of his publications, sound recordings, films, photographs, genealogies, crayon drawings, maps and other illustrations will remain as this tireless worker's legacy. The lasting significance of this data lies neither in its bulk nor its scope, but in the fact that it was gathered with a focused goal in mind, to describe the diversity of an entire people before transformation by European contact. Tindale was well aware that his attempt to do this, as symbolised by his 1974 map of 'Aboriginal Tribes of Australia' and its accompanying compendium, would never be fully acceptable and that, indeed, its chances of acceptance would diminish as more and more scholars entered the field. Nevertheless, when he began his task in the 1920s, the number of practising anthropologists in Australia could be counted on the fingers of one hand, and he believed in his ability to complete the task, although he once confided in this author that he didn't have time to die until about 2020.

A side of Tindale's career which his many achievements tend to obscure is that concerned with his role as a public servant. Tindale represented the public face of anthropology in South Australia for almost half a century. He pronounced upon controverial issues and developments in the 'Advertiser' and other Adelaide newspapers, gave lectures and radio talks, and answered innumerable public enquiries about Aboriginal place names, archaeological finds and so on. Tindale had been a founding member of the Anthropological Society of South Australia during 1926 and he continued to participate in its activities and administration. His advice was directly sought by government upon such issues as the creation of a reserve for Pitjantjatjara people in South Australia's north-west during the 1930s, and the policy issues arising out of his survey of what had become known as the 'half-caste problem', documented during the 1938–39 expedition. Tindale also found time to apply his anthropological expertise and experience of other museums to new exhibits. He undertook a full-scale renovation of the Museum's Pacific Gallery shortly after his return from war service during 1946. He superintended the construction of an Indonesian Hall during 1952–54 (since dismantled) dealing with the cultures and history of the Asian-Pacific region., and periodically made important changes to the Museum's long-standing Aboriginal display in the Stirling Gallery. His role as an 'expositor of science' (Day 1966) was best exemplified perhaps by his co-authorship of three popular children's books on the subject of indigenous peoples. 'The First Walkabout' (1954, Longmans), written with H. A. Lindsay, was awarded a prize for the best Australian children's book of the year in 1955. Another successful historical novel, 'Rangatira. A Polynesian Saga', also co-written with Lindsay,

was published in 1959 (Rigby), followed by a factual illustrated children's book, 'The Australian Aborigines' (1971, Lloyd O'Neill), co-written with his daughter Beryl. Tindale was a committed bibliophile, but as a user, rather than an owner. His own extensive reference library was often annotated and full of bookmarks. His early exposure to the Adelaide Public Library collection enabled him to save many important reference works marked for the discard pile; these are now incorporated within the South Australian Museum library. Tindale was a great advocate for binding library volumes. He served as honorary libarian to the Royal Society of South Australia from 1952 to 1966, as its Secretary during 1935 and as President during 1949.

There is no doubt that Tindale had developed formidable skills as an administrator and policy-maker during his long career. It was unfortunate that Herbert Hale's postponement of his own retirement made it impossible for Tindale to be considered as an applicant for the job of Director at the South Australian Museum. Tindale acted in this position from 1959 until 1960, having spent the previous year as Visiting Professor of Anthroplogy at the University of California in Los Angeles. The lack of opportunity in Adelaide made the decision to take further American academic postings easier. Tindale spent terms as Visiting Professor of Anthropology at the University of Colorado from 1966–67 and from 1970–71, and a further term at UCLA from 1967–68.

This academic recognition in America, where Tindale gained a widespread reputation among students and fellow academics for his lecturing skills, culminated in the University of Colorado's award to him of an honorary doctorate during 1967, the result of John Greenway's initiative. Australian recognition was less forthcoming. Through Professor Derek Freeman Tindale was awarded a Research Fellowship to the Australian National University during 1973, in company with his long-term colleague and friend Joseph Birdsell. This posting enabled him to complete the final details for his major work, 'Aboriginal Tribes of Australia: Their Terrain, Environmental Controls, Distribution, Limits, and Proper Names', a compendium of data dealing with every known Aboriginal group in Australia. Often criticised, both at the level of detail and for its controversial definition of 'tribe', the book and accompanying maps remain incontrovertibly as a classic work of Australian anthropology.

Tindale was awarded the Verco Medal of the Royal Society of South Australia during 1956, the Australian Natural History Society Medallion during 1968 and the John Lewis Medal of the Royal Geographical Society of Australasia during 1980. During that year also, Tindale was awarded his second honorary doctorate, by the Australian National University. By this time though, Tindale had made his home in America. His wife of forty-five years, Dorothy May, had died of leukemia during 1969. She had accompanied him, together with the Birdsells, across Australia on the 1938–39 Harvard-Adelaide expedition, and had encouraged an appreciation of anthropology in their two children, Anthony and Beryl. In 1970 Tindale married an old family friend, Muriel Nevin, whom he had first met in Honolulu during his 1936 Carnegie Fellowship visit to America. Apart from occasional research trips to Australia and butterfly collecting trips elsewhere in North America, they continued to live at Palo Alto near Stanford University in Muriel's small timber house, bursting at the seams with his research materials, library, and butterfly specimens. An adjacent shed provided more storage space and a workbench for constructing his neat wooden butterfly boxes.

While Tindale relished the relative seclusion of his retirement in the United States, he was never aloof from family or friends. It became almost standard for Australian anthropologists and linguists visiting America to adjust their itineraries to take in a side-trip to discuss points and issues with 'Tinny'. A boyish sense of humour, a readiness to engage with researchers on their own terms, and an enthusiasm for new information sustained him through accidents and episodes of ill health from his mid-80s. He impressed all visitors during his later years with the same qualities recorded by earlier colleagues—an indefatigable commitment to making an enduring record of Aboriginal life before the transformations wrought by European contact. His career's output of several books and nearly 200 scientific papers on anthropology, geology and entomology were used as working texts for future papers; he did not preserve bookshelf copies of any of his publications. By 1989 he knew that he would not complete his Milerum book, nor several other projects. Unfazed, he scaled his work programme back and supplied data for Aboriginal place names to the South Australian Department of Lands. He was never happier nor more animated than when confirming a new detail and putting it on the record for others to use.

Tindale remained an Honorary Associate of the South Australian Museum until his death, an association which spanned more than seven decades. During this time all of his former colleagues had left the scene and he observed the gap between museum and academic anthropology develop, widen, but then, encouragingly, begin to close. His letters to the Museum were like those from someone who has stayed away in the field too long: they were always completed with the touching epigram, 'Please give greetings to all those who remember me'. During 1993 Tindale received unofficial confirmation of the award of Officer in the Order of Australia; this was presented posthumously, to his widow Muriel. But the South Australian Museum Board's 1993 decision to name a public gallery in his honour may have meant most to him—a 'museum man' to the last.

The last word, and most cogent summary of Tindale's achievements, rests with an old friend and scientific colleague, Professor W. V. MacFarlane, writing in support of Tindale's honorary doctorate from the University of Colorado:

> It is not common in our time to find men with the skills and insights which Mr Tindale has shown through his active and productive life. He is basically a scientist, while skills with language and human relations fit him for anthropology. His special interests in entomology, geology and botany broadened the scope of his ethnographic studies. As the use of film, tape, carbondating and blood grouping came into anthropological work he readily made use of these for the data that they could bring towards his final synthesis of the cultural history of the Aboriginals in time and space. In addition, Mr Tindale has shown throughout his work a tolerance, humility, honesty and adaptability which made it easy for him to find collaborators amongst both black and white men. (MacFarlane 1966)

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This bibliography is arranged chronologically under four headings: Ornithology and Botany (10 entries), Geology and Palaeontology (11 entries), Entomology (42 entries), and Anthropology (135 entries).

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OBITUARY

JOSEPH B. BIRDSELL

30 March 1908 – 5 March 1994

Joseph B. Birdsell was born in South Bend, Indiana on 30 March, 1908 and died in Santa Barbara, California on 5 March, 1994. Known as 'Jo' to his colleagues and friends, Birdsell spent his academic years mostly at the University of California, Los Angeles, where he taught from 1947 to his retirement as Professor of Anthropology in 1974. His scholarly life as a physical/biological anthropologist started with a Ph.D. from Harvard in 1941 where he was trained by Hooton, Boyd and later influenced by Clyde Kluckhohn. His work and publications spanned five and a half decades of fieldwork in Australia, teaching at UCLA and writing on a broad range of subjects. Two valuable retrospective commentaries are available on his work. A volume of essays in his honor appeared in 1981, and Shanklin's and Mai's (1981) article provides an overview of his life and an appraisal of his conceptual work. Birdsell (1987) himself, also offered discussion of major intellectual influences on his scholarly growth in a general review which appeared about eight years ago.

For those of us who had Jo as a teacher, the experience conveyed the power of his ability to relate empirical facts to model building to understanding how evolution operates as a broad orchestration of Darwinian principles in micro-evolutionary changes, and to the analyses of issues as diverse as race, racism and population ecology. This obituary discusses Birdsell's contribution to the study of the Australian Aboriginal, his overall impact on biological anthropology and the kinds of influences which his writings have had on the field, and finally my own personal reflections on the man and his ideas.

Birdsell's fieldwork and publications on the Australian Aboriginal were always linked with his colleague Norman B. Tindale. It was Tindale through Hooton who brought up the idea for Birdsell to work in Australia in 1938, the start of the first Harvard-Adelaide joint venture. It was during this two year period that Birdsell and Tindale collected a vast range of data from blood samples to phenotypical features on a broad spectrum of Aboriginal populations from Queensland to Tasmania and Western Australia. Later, in the early 1950s, both scholars carried out two more years of fieldwork which focused on the Kimberley and the northwest part of Australia. The Birdsell–Tindale collaboration, which lasted for nearly fifty years, permitted each scholar to develop a diversity of theoretical and empirical concerns about which they could exchange ideas and mutually play off one another. Birdsell's commitment to empirically grounded theory

represents a lifelong development which is initially apparent in his 1941 dissertation from Harvard and continues through to his recent massive 455 page volume which summarises more of his empirical findings an Australia (Birdsell 1993).

Birdsell's contributions to the biological analysis of Aboriginal Australians covers three areas: the trihybrid theory of origin, the issue of dating Homo sapiens' first entrance to continental Australia, and a focus on the continental level of evolutionary developments. Prior to Birdsell's analysis, the overwhelming view was that the Australian Aboriginal was a single, homogeneous population which spread throughout the continent, and the dating indicated recent human arrival in Australia possibly as recently as 5 000 to 6 000 years ago. Furthermore, most of the physical anthropology of Australia stressed only local and regional developments in the fossil record. Birdsell saw the problem along broader continental perspectives which related the particular to the whole of Australia and also compared the Australian situation to population processes in southeast Asia, East Asia and Africa.

In identifying the problem of origins as one of micro-evolutionary differences related to differential ecological and population forces, Birdsell argued that the category 'Australoid' was simply wrong and should be abandoned. In his writings in the 1940s and also in his 1993 volume, Birdsell claimed that Australia was inhabited by three waves of population expansion: the Barrinean wave with Negritic features similar to some southeast Asian populations, the Murrayian wave with affinities to Ainu-like groups (the original inhabitants of Japan), and the Carpentarians with Veddoid features. The trihybrid hypothesis addressed the concern that the previous Australoid categorisation embraced significant internal variation thus blurring micro-evolutionary processes as well as other hypotheses of internal migration within Australia.

While proposing the trihybrid theory as it related to broader processes within the Asian context, Birdsell also speculated that early man arrived in Australia at least 35 000 years ago if not earlier. In the 1940s when Birdsell suggested this early inhabitation of Australia, his claim was anathema to most scholars in Australia. There were no C14 dates, very few fossil remains and the commonly accepted scholarly idea was that humans entered Australia only 6 000 years ago.

Both of these opinions made Birdsell and his views totally unacceptable to biological anthropologists and comparative anatomists in Australia. When I arrived in Sydney in 1966 to start fieldwork in the Centre, I was asked by many academicians at the University of Sydney and elsewhere what had stimulated my interest in Australia. Although I had a Ph.D. from the University of Chicago based on fieldwork among the Mandaya of southeast Mindanao, Philippines, it was Jo Birdsell who had whetted my intellectual appetite for working in Australia. When I mentioned Birdsell's name, I was simply laughed at, no one took Birdsell seriously. This attitude held for most Australian Aboriginal scholars (except for W. E. H. Stanner). Late in the summer of 1966/1967, I met A. A. Abbie at Amata in the Musgrave Ranges. When Abbie heard me talk about Birdsell as pivotal to my working in Australia, he quickly and quietly walked away. However, by 1974 when C14 dating indicated that 30 000 B.P. was plausible for the earliest date of human entrance into Australia, Birdsell and Tindale were honored with a conference held in Canberra, and Birdsell was asked to spend a year at the Australian National University. Yet, by the late 1970s, even Birdsell's estimates were viewed with caution, since C14 dates had pushed human entrance back to 45 000 to 50 000 B.P.

Birdsell's early speculations and visions were based on a well developed idea of population genetics combined with migration theory which stressed the rapidity by which early hominoid forms could move from South and East Africa to the Asian mainland. These interests indicated that Birdsell saw local and regional changes and developments from a broader continental and even global perspective. Birdsell's (1951) lengthy article on the peopling of the Americas applied the same perspective by attempting to extrapolate what could be said about the Americas from Asia. To this day, most of his generalisations have been validated, with subsequent archaeological research supporting his early speculations, just as they did within the Aboriginal Australian context. C14 dates from the Bering Straits, as well as those from the extreme tip of South America, add credence to his early 'educated speculations'.

Although Birdsell's lifelong interest in Australia was well anchored in the history of physical and biological anthropology in the United States, his intellectual aim even as early as the 1940s was to forge the foundations of the new systematics from biology and genetics to physical anthropology, where for decades the dominant concern was primarily taxonomic and phenotypical analysis which had no bearing on

ideas of evolutionary biology. This new paradigm meant that physical and anthropologists had to turn to the works of Mayr, Dobzhansky, Haldane, Simpson and Fisher as they established a true and vital evolutionary basis for the study of human populations. But of all the evolutionary biologists who were critical to the new physical anthropology, it was Sewall Wright's writings which had the greatest impact on how Birdsell understood micro-evolutionary processes and the extent to which population genetics related to broader evolutionary forces. Birdsell's fifty-five years of analysis and writing all addressed the multi-facets of evolutionary issues and Mendelianism as Wright envisioned the problem, and Birdsell's comprehensive 1993 volume is dedicated to Wright.

As a biological anthropologist representing the new systematics in biology, Birdsell's writings represent a broad range of interests covering population genetics, primate studies, racial analysis, environmental regulation among hunting and gathering populations, analysis of the paleontological records along spatial axioms, and the rigorous application of modeling to understanding population processes and diachronic changes. The application of population genetics to human societies was most problematic when Birdsell first entered academia. Fruit flies and controlled populations were ideal to ascertain how evolutionary forces worked in a population, but the human scene, even hunting and collecting societies, was too complex and variable as a unit of analysis. Jo saw the problem as one which required both a strict conceptual definition of population and a realisation that certain evolutionary processes simply could not be limited to the population *per se*. Thus, his use of genetic space and gene flow models was the beginning of cline analysis in small populations in which spatial models on a regional or continental scale were necessary for understanding microlevel changes. Furthermore, Birdsell's investigation of international drift and mutational processes among western desert Aboriginal groups was among the first direct application of Sewall Wright's (1931, 1939, 1978) theories to human populations. Until Birdsell's analysis, genetic drift has been employed as a factor only if no other evolutionary process could explain the observed variation. Also following Mayr (1942), Birdsell pioneered in understanding the dynamics of the founder effect among small human societies. Systematics in biology reached a new plateau when Birdsell took their insights and re-thought the genetic basis of human societies.

In 1953, Bartholemew and Birdsell published a pivotal and now classic article on protohominids. Although this analysis was not empirical, it established the agenda in regard to how comparative primate studies should be approached. By establishing a baseline from data on non-human mammals and comparing this with hunting and gathering societies, the authors created a framework of the biological and minimal cultural attributes which protohominids must have expressed. Over the past four decades, primate studies have filled in the empirical foundations through field studies, and, Birdsell's plea for integrating population genetics and social ecology resonates in each particular case study. Even the interest in vocal behaviour is found in this central piece, and the past three decades again demonstrate the clarion call of this highly creative and venturesome kind of thought.

Birdsell's form of ecological analysis, especially in analysing the Australian data, indicated that certain demographic and environmental regulations were present. Spacing mechanisms, both spatial and demographic, were essential in determining how hunters and gatherers survived. A number of his papers, the most general one being in the 'Man the Hunter' (1968) volume, set forth the essential dynamics of spacing, one of which was preferential female infanticide. Infanticide is common in hunting and gathering societies, however, the stress on preferential female infanticide must be revised and questioned as a universal feature among such societies (see Yengoyan, 1981). Nevertheless, it was Birdsell's direction and thinking along such lines that has stimulated reconsideration of such issues. Birdsell's stress on population characteristics (fertility, fecundity, mortality rates, morbidity, population control, the population pyramid, rates of in-migration and out-migration) was based on the assumption that demographic variables are the connecting link between environmental factors (eg rainfall) and social organisation/structure. This type of ecological analysis was markedly different from Julian Stewart's idea of cultural ecology, and in most respects avoided the pitfalls of Stewart's conception of the culture core.

His interest in population dynamics was not limited to the Australian case. His 1953 paper drew the connection between mean annual rainfall and Aboriginal population densities in Australia, and his analysis has been duplicated in other areas of the world such as the Great Basin in the western United States. In my opinion, Birdsell's

most original and creative thinking about paleontological issues was published in 1957. By working through various models of population dispersion and the effects of how and when a population buds off from a parental population into unoccupied lands, Birdsell first asked the question: 'how fast could early man occupy continental Australia?' Using a relatively conservative assumption that populations would double in each generation when entering unexploited territories, Birdsell concluded that early man could have spread throughout Australia (and Tasmania) within a period of 7 000 years, which in evolutionary terms is virtually nothing. From this framework, Birdsell asked how fast would the Intrinsic Rate of Increase (IRI) be from South/East Africa through the Middle East, India, Southeast Asia and to Australia? He concluded that the time differential would have been from 22 000 to 25 000 years, which again is an evolutionary split-second. Thus, the old idea that isolation and slow population growth were barriers to human expansion had to be dismissed simply from what is known of population and demographic processes. This particular paper has led to a rethinking of the whole fossil-man story, and the picture is still far from complete, but the essential parameters were set forth by Jo in his usual insightful way, a mix of good empirical observations combined with a creative and fertile approach to problems. Without this essential creativity, palaeontologists simply could not analyse their data productively, even if the fossil record were nearly complete.

Birdsell's collaboration with Carleton Coon and Stanley Garn (1950) represents the first major break in the study of race and racial formation. Under Hooton and other physical anthropologists throughout the first five decades of this century, the notion of race was based on a set of phenotypical features which could be measured and compared, but these features had little or no adaptive utility. Thus, Hooton conceived a race as a cluster of non-adaptive features based primarily on forces of inheritance, although virtually nothing was known about inheritance and genetic transmission. While the distribution of blood type alleles was known to manifest different proportions according to race, as a taxonomy, racial classification was dealt with in a virtually non-biological way.

The Coon, Garn and Birdsell approach moved away from gross phenotypical contrasts and stressed race as a continuing historical process of adaptation to particular broad environmental forces. Furthermore, race was treated as a micro breeding unit through which one could show how various markers are transmitted as specific genetic features which ideally can be related to gene frequencies. It was on the level of local Mendelian populations or breeding units that race manifested and expressed evolutionary processes. In the 1940s, these ideas were highly important, since for the first time they moved the study of racial formation to specific environmental and biological parameters which acted selectively with the genotypoe as well as certain phenotypical features.

My initial contact with Jo Birdsell was in 1956 when I enrolled in the Department of Anthropology as the first year graduate student at ULCA. Coming in with only three undergraduate anthropology courses meant that virtually everything I encountered was new, exciting and challenging, and during my two years at ULCA I took Jo's undergraduate courses as well as his seminars. Jo's style of lecturing was inspiring to all his students in that he conveyed a deep knowledge of the subject matter combined with an openness of ideas which provoked students to challenge him on the spot. Above all, he insisted that we work through ideas and clusters of data in a method in which "educated speculation" emerged as a means of seeing new problems derived from older and possibly less interesting issues. It was in these seminars that we had a chance to work through various ideas which he was developing and which soon appeared in the journals.

Furthermore, a few of us worked for him tabulating his data from his first field trip to Australia as well as his last one in the early 1950s. Clyde Wilson, Robert Littlewood and I spent hours in the late afternoons, evening and sometimes on the weekends tabulating all the findings on a single variable. It was this experience which brought forth Jo's insistence that incorporating maximum biological, social and interactional data on a genealogical grid was the most essential strategy in dealing with a vast range of data. His genealogies were impressive, and, being a neophyte, I was always wondering what it meant and where was it going. Thus he was a gifted teacher, one who was articulate beyond expectation, one who knew his subject matter, and one who knew how to think about his data in a venturesome and creative way. At the same time we all sensed that his broad and bold thinking would culminate in a work which was readily approachable. In 1972 Birdsell published a textbook titled 'Human Evolution', a book

which has since gone through various editions. Reading Jo's textbook is equivalent to hearing vintage Birdsell in person. Ideas abound on the pages, the case studies and data are fascinating, and his ability to convey a broad spectrum of issues, concerns and doubts in an engaging way express an intellectual love of his subject matter that never waned.

Two different styles of Jo's pedagogy should be noted. First was his insistence that empiricism was fundamental to what biological anthropologists must set forth as theories or as hypotheses. Models and the craft of modeling were based on empirical knowledge, but Birdsell always felt that empiricism could only take one so far. There are some limits to explanation and interpretation intrinsically due to a lack of information, but the wisdom and experience that students received from him were that one need not be curtailed and/or limited by empiricism. Educated speculations were as valid as pure empirical information, and in most cases the speculations were more interesting and led to a discussion of new problems and future kinds of research.

Second was Jo's insistence on examining problems, issues and debates in a different and unique way. Here Jo would ask what an event, thing, theory or strategy could not be. By focusing on conditions which either empirically and/or logically could not be the case, we were forced to imagine the range of all possibilities, even if some of these simply could not occur. In each case, the feasibility of the occurrence of an event or thing compelled seminar participants to show the empirical basis and/or logic relating to the presence and absence of factors. In contemporary philosophy this form of analysis is called counterfactual thinking, and it has had an important effect on the way that philosophical and logical arguments are crafted. Birdsell understood this form of thought well before it came into vogue. Nearly four decades after that two year experience with Jo, the impact of his thought and the way he saw problems is still central to my own work.

After finishing an MA at UCLA in 1958, I moved on to the University of Chicago to pursue my doctorate in social anthropology. For the following thirty to forty years, Jo and I were in communication on various Australian matters, especially every time I returned from Australia.

It goes without saying that he will be sorely missed by his friends and former students. The experience of his seminars, of seeing him craft an argument, either on paper or verbally, and the kind of deep probing which he asked of himself and his students will all be missed. Those of us who experienced the man hold him in deep appreciation and are much in his debt, for there will never be another 'Jo' in our midst.

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THE WATER SKINKS (LACERTILIA: *EULAMPRUS*) OF VICTORIA AND SOUTH AUSTRALIA

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HUTCHINSON, M. N. & RAWLINSON, P. A. 1995. The water skinks (Lacertilia: *Eulamprus*) of Victoria and South Australia. *Records of the South Australian Museum* **28**(2): 185–207.

The taxonomy, biology and distribution of the Victorian and South Australian water skinks of the *Eulamprus quoyii* species-complex are reviewed. A lectotype is designated for *Scincus vittatus* Quoy & Gaimard, 1824. Five taxa are recognised: *E. quoyii* Duméril & Bibron from the lower Murray River valley and Mt Lofty Ranges, *E. heatwolei* Wells & Wellington from warm temperate eastern Victoria and the Fleurieu Peninsula, *E. kosciuskoi* Kinghorn from alpine northeastern Victoria and *E. tympanum* Lönnberg & Andersson, the latter with two subspecies, *E. t. tympanum* (including *E. herseyi* Wells & Wellington, 1985), widespread through cool temperate habitats and *E. t. marnieae* ssp. nov., restricted to the stony rises east and north of Lake Corangamite where its survival is threatened by habitat degradation.

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Manuscript received 31 October, 1994.

The water skinks form a group of closely related medium sized to moderately large (SVL to 118 mm) Australian lygosomine scincid lizards that inhabit the margins of watercourses throughout the coastal drainage systems of eastern and southeastern Australia (excluding Tasmania). Water skinks are conspicuous, active diurnal heliotherms (Spellerberg 1972b) which readily use water as a refuge, swimming on and under the surface (Daniels & Heatwole 1990).

Traditionally these lizards have been placed in *Sphenomorphus*, either as a subgenus of the catchall *Lygosoma* (Smith 1937) or, following Loveridge (1934) and Mittleman (1952), as a full genus. Recent Australian usage (Cogger 1992, Greer 1989, 1992) has recognised the paraphyletic nature of *Sphenomorphus* (see Greer 1979a, Greer & Parker 1967) by employing the long-disused name *Eulamprus* Fitzinger (type species *quoyii*) for the larger Australian viviparous *'Sphenomorphus'*, including the *E. quoyii* complex. As yet there has not been a rigorous phylogenetic assessment of this assemblage, but Shea & Peterson (1985) and Greer (1989, 1992) discuss some potentially useful characters which indicate that *Eulamprus* is at least more likely to be a natural unit than the much larger and obviously heterogeneous assemblage represented by *Sphenomorphus*, and it is provisionally accepted in this paper.

The first described member of this group was Quoy & Gaimard's (1824) *Scincus vittatus*, the 'Scinque à flancs noirs', from the Sydney region. Duméril & Bibron (1839) redescribed the species using the replacement name *Gongylus (Lygosoma) quoyii*, and as *Lygosoma* or *Sphenomorphus quoyii*, the water skink has become a familiar and relatively well-studied eastern Australian lizard (e.g. King 1964, Veron 1969, Spellerberg 1972a–d, Daniels 1987).

Early workers in Victoria and South Australia (Lucas & Frost 1894, Waite 1929) were familiar with a lizard they referred to as *Lygosoma quoyii*, although specimens from southern Australia do not conform in all respects to the east coastal populations. Two new water skink taxa were described during the early part of this century, *Lygosoma tympanum* from near Melbourne (Lönnberg & Andersson 1913) and *Hinulia quoyii kosciuskoi* from Mt Kosciusko (Kinghorn 1932). Loveridge (1934), in spite of some uncertainty, synonymised *kosciuskoi* with *tympanum*, treating the latter as a southern and highland subspecies of *quoyii*. Worrell (1963) recognised *tympanum* as a full species, distinct from *quoyii*, but did not query the synonymy of *tympanum* and *kosciuskoi*.

Rawlinson (1969) reported that *tympanum* and *kosciuskoi* were distinct species, and that both were distinct from *quoyii*, the three being collectively referred to as the *Sphenomorphus*

[1] Peter Rawlinson died in April 1991. His unpublished studies of type material and his taxonomic insights form the basis of this paper.

quoyii species complex. He also reported a fourth, undescribed member of the complex, referred to as the 'Warm Temperate' form of *S. tympanum*. The data on which Rawlinson's conclusions were based were not presented at the time but these conclusions have become widely used (Cogger *et al.* 1983).

Five species of water skinks are recognised by Cogger (1992). In addition to *Eulamprus quoyii, E. tympanum* and *E. kosciuskoi, E. heatwolei* Wells & Wellington (1984) is applied to New South Wales populations of Rawlinson's 'Warm Temperate' form of *E. tympanum* (Shea & Peterson 1985, Cogger 1992) while *E. leuraensis* Wells & Wellington (1984) is applied to the Blue Mountains population formerly referred to *E. kosciuskoi.*

Shea & Peterson (1985) have summarised data pertinent to New South Wales water skink populations but variation in the southerly parts of their distributions is not well documented and the distributions themselves are not mapped with sufficient resolution in Cogger's books. Much of what is known, including the taxonomic distinctiveness of *tympanum* from *quoyii* and in turn of *heatwolei* from *tympanum* stems from unpublished work of the second author. In addition, a hitherto unreported, morphologically distinctive population of water skinks has been found in central southwestern Victoria. The purpose of this paper is to stabilise the nomenclature, document the distinguishing features and geographic distribution of the four described water skinks in Victoria and South Australia, and to describe the newly discovered Victorian form.

Materials And Methods

The specimens on which this study is based are primarily those of the Museum of Victoria (NMV) and the South Australian Museum (SAMA). Except where indicated, specimen descriptions are based only on Victorian and South Australian specimens. Other Museum abbreviations used here (following Leviton *et al.* 1985) are: AMS, Australian Museum, Sydney; BMNH, Natural History Museum, London; MNHN, Muséum Nationale d'Histoire Naturelle, Paris; NHRM, Naturhistoriska Riksmuseet, Stockholm; NMW, Naturhistorisches Museum, Vienna.

Head shield terminology used in this paper is illustrated in Figure 1. Supraciliaries were counted to the last scale in contact with both the upper palpebrals and the supraoculars. Presuboculars are the scales between the posterior loreal and the subocular supralabial. The postsubocular scale row is formed by the series of scales beginning on the orbital margin of the postsubocular supralabial and running dorsally to the posterior supraciliary. The last infralabial was difficult to distinguish from adjacent scales when the mouth was closed; it was identified here as the last scale contacting the ventral margin of the last supralabial. Scale counts were made using standard criteria (e.g. Greer 1982). Shea & Peterson (1985) employed a different method for counting paravertebral scales than the one used here: they stopped the count at the level of the anterior edge of the hind limb, whereas we followed Greer (1982) in taking the counts posteriorly to the first scale posterior to a line level with the posterior edge of the hind limb held at right angles to the body. This count estimates the number of scales overlying the trunk vertebrae (including the sacrals). Measurements of snout–vent length (SVL), tail length and hind limb length (HLL) were made to the nearest millimetre using a ruler. Head width (HW, measured across temporal jaw muscle bulge) and head length (HL, measured from snout to anterior edge of ear opening) were measured using dial calipers to the nearest 0.1 millimetre. Size at sexual maturity was estimated from smallest female with enlarged ova or male with enlarged testes. Osteological data were obtained primarily from the water skink skeletal collection assembled by S. J. Tilley, now in the collection of the Museum of Victoria.

Systematics

SCINCIDAE Gray, 1825
LYGOSOMINAE Mittleman, 1952

Eulamprus Fitzinger, 1843

A group of lygosomines belonging to the *Sphenomorphus* Group (Greer, 1979b), sharing the derived features of moderately expanded palatal rami of the pterygoids and viviparous reproduction, but lacking the derived character states of other members of this Group. Within this genus, the *E. quoyii* species group shares four derived character states: third pair of chin shields separated by five smaller scales; inguinal fat bodies absent; distal supradigital scales in a single row; subdigital lamellae grooved, divided basally (after Greer 1989).

Other features shared by all species in the complex are as follows. Nasals separated medially. Supranasal and postnasal scales absent.

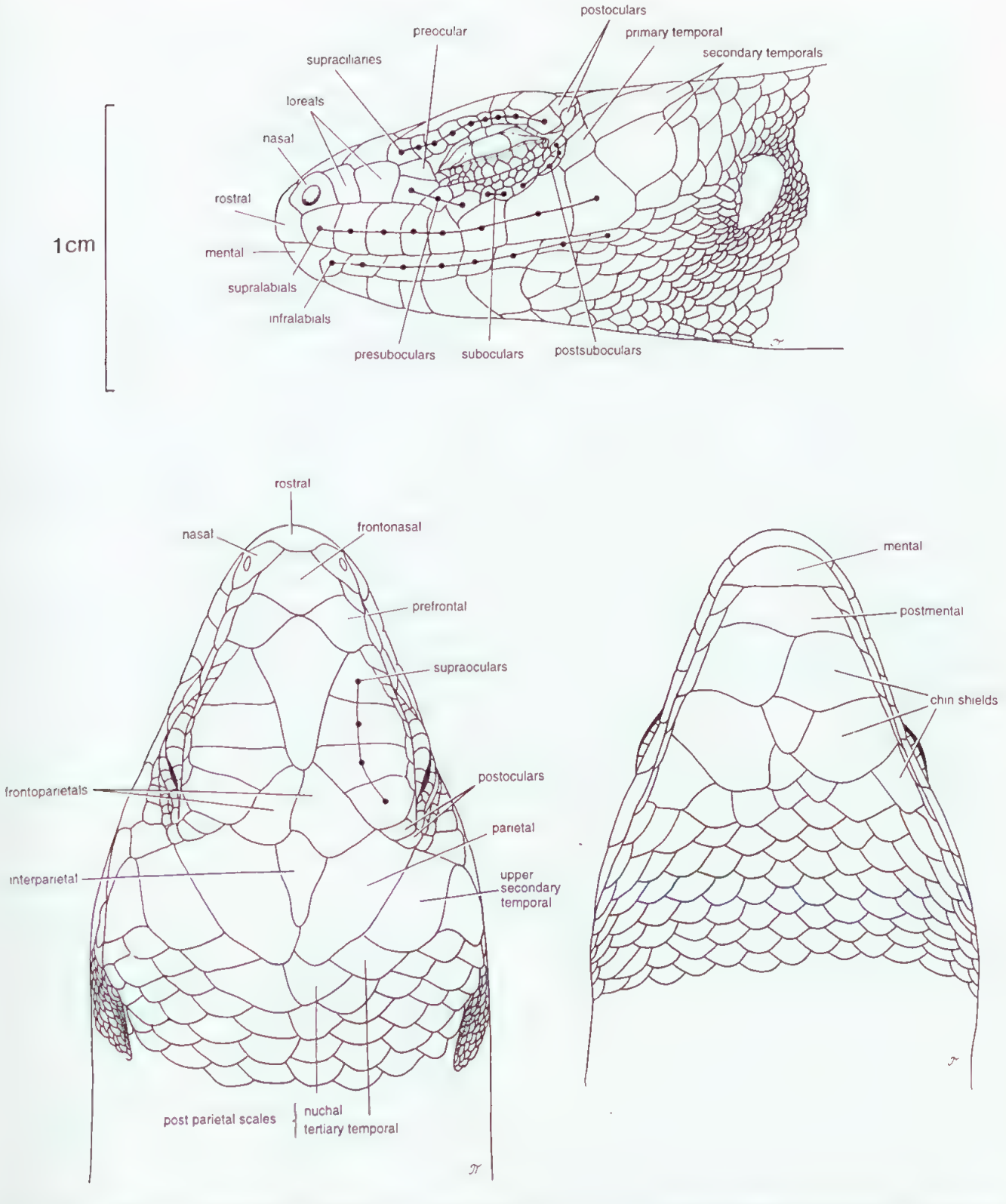

FIGURE 1. Head of a water skink (*Eulamprus t. tympanum*; NMV D50716) showing head shield nomenclature used in this paper.

Two subequal loreals. A single preocular. Lower eyelid scaly. Three presuboculars, the third penetrating downwards in front of the subocular supralabial. Two or three subocular scales. Four supraoculars, the first three (rarely first two) contacting the frontal. Two or three postoculars lie between the posterior supraciliary and the parietal; the dorsalmost and often the largest of these could be regarded as a small fifth supraocular, and its designation as a postocular here is arbitrary, reflecting traditional treatment of these species (e.g. Cogger 1992) as having only four supraoculars. Frontoparietals paired; interparietal distinct. Primary temporal small, variable

intraspecifically, sometimes scarcely distinct from postsubocular scales. Upper secondary temporal longer than deep, contacting lateral margin of parietal scale and bordered below by single lower secondary temporal which is deeper than long; upper temporal may be divided by a vertical suture and lower by a horizontal suture in a minority of specimens. First pair of chin shields in broad median contact; second pair separated by a single scale. Ear opening large, three-quarters the size of the eye, its margin smooth-scaled and without projecting auricular lobules. Median pair of preanals much larger than lateral preanals.

Water skinks show ontogenetic variation in two significant scale characters. In the *Sphenomorphus* Group, each parietal is usually bordered along its posterior margin by a transversely enlarged nuchal (medially) and along its lateral margin by the upper secondary temporal and an additional large scale intercalated between the nuchal and the upper secondary temporal. Most adult water skinks, the alpine species excepted, lack this scale morphology, having instead four or five variably enlarged and often obliquely oriented and asymmetrically arranged scales filling the gap between the upper secondary temporal on each side. Neonates (Fig. 2), however, have the more common lygosomine arrangement of two transversely aligned nuchals. Positive allometric growth of the upper secondary temporal relative to the parietal appears to crowd the post-parietal scales in adults. Water skinks as subadults and adults have smooth body scalation but neonates have all dorsal and lateral body, tail and limb scales keeled, with up to four low keels or pustules on each dorsal scale producing a wavy trailing edge. The scales become smooth and cycloid as the carination is lost at a snout vent length of about 40–45 mm.

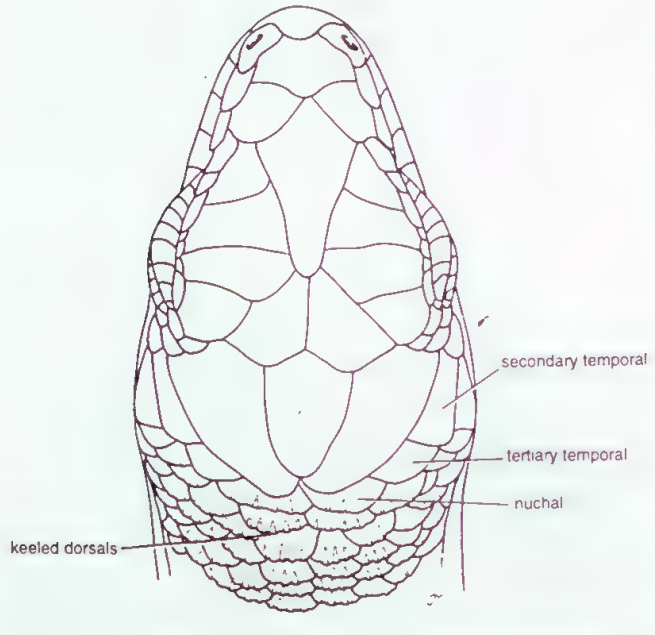

FIGURE 2. Head and forebody of a neonate water skink (*Eulamprus t. tympanum*; NMV D13654). showing the arrangement of post-parietal scales (compare to Fig. 1) and the keeled dorsal body scales present in juveniles but lost early in ontogeny.

Presacral vertebrae 26. Phalangeal formula of manus and pes 2.3.4.5.3 and 2.3.4.5.4 respectively. Postorbital bone present, intraspecifically variable in dorsal exposure from elongate and extending to the supratemporal fenestra to greatly reduced and restricted to the region of thejugal articulation. Supratemporal fenestra large. Ectopterygoid without or with variably developed palatal process which may extend to the palatine, excluding the pterygoid from the infraorbital vacuity. Hemipenis elongate with deep distal bifurcation. Iris of eye black, indistinguishable from pupil in life.

The water skinks show slight sexual dimorphism in proportions, females reaching a slightly larger SVL and males having relatively longer limbs and larger heads. Within species, dimorphism becomes more obvious with increasing body size. Both sexes attain sexual maturity at similar sizes.

Eulamprus quoyii (Duméril & Bibron, 1839)
(Figs 3–4)

Scincus vittatus Quoy & Gaimard, 1824: 178. Lectotype (designated herein): MNHN 7112, Neutral Bay, Port Jackson, New South Wales, F. Péron. (Junior homonym of *Scincus vittatus* [= *Mabuya vittata*] Olivier, 1804).

Gongylus (Lygosoma) quoyii Duméril & Bibron, 1839: 728. Lectotype (Wells & Wellington 1985): MNHN 7113, Neutral Bay, Port Jackson, New South Wales.

Eulamprus quoyii Fitzinger, 1843: 22.

Hinulia quoyii Gray, 1845: 70.

Hinulia gastrosticta Günther, 1875: 11. Lectotype (Wells & Wellington 1985): BMNH 1946.8.15.34 'Queensland', purchased from G. Krefft.

Lygosoma (Hinulia) quoyii Boulenger, 1887: 230.

Sphenomorphus quoyi Barbour, 1914: 204.

Sphenomorphus quoyii quoyii Loveridge, 1934: 349.

Lygosoma (Sphenomorphus) quoyi Smith, 1937: 220.

Eulamprus gastrostictus Wells & Wellington, 1984: 93.

Types

As the oldest available name relating to this group of lizards, Duméril & Bibron's (1839) *Gongylus (Lygosoma) quoyii* must be confidently allocated before other names can be applied. Five syntypes used by Duméril & Bibron are still identifiable in the MNHN collection, four of which are members of the *E. quoyii* species complex, the fifth (7114) being a specimen of the Asian species *Scincella reevesi*. Of the remaining four, two (7112–13) were collected by Péron and are identified by the MNHN as syntypes of *Scincus vittatus* Quoy & Gaimard. Both have a colour pattern which includes well-developed narrow pale dorsolateral lines, matching the figure provided by Quoy & Gaimard (1824) and the description of Duméril & Bibron (1839). The remaining syntypes, 2976 (Port Macquarie, J. Verreaux) and 2977 (Nouvelle Hollande, Lesson et Garnot) are conspecific with 7112 and 7113. Examination of the types thus confirms that the current taxonomy is correct in applying the name *quoyii* to the east-coastal Australian member of the complex. One of Quoy & Gaimard's syntypes, 7113, SVL 105 mm, was designated by Wells & Wellington (1985) as the lectotype of *Gongylus (Lygosoma) quoyii* Duméril & Bibron, 1839. This specimen is not in good condition, the mouth and neck being badly mutilated; however there is no doubt of its specific identity . The other syntype, 7112, is in excellent condition and would have been a better choice. It is hereby designated as the lectotype of *Scincus vittatus* Quoy & Gaimard, 1824.

Four syntypes of Günther's *Hinulia gastrosticta* are in the collection of the Natural History Museum, London (BMNH 1946.8.4.99 and 1946.8.15.34–36) and two more identified as 'Typus' are in the NMW (16656:1–2). All six are conspecific with the lectotype of *Gongylus (Lygosoma) quoyii*, confirming the correctness of Boulenger's (1887) synonymisation of *gastrosticta* with *quoyii*. One of the BMNH syntypes, 1946.8.15.34 (at 101 mm SVL, the largest of the four), was designated as lectotype of *Hinulia gastrosticta* Günther, 1875, by Wells & Wellington (1985) who gave no reason for resurrecting the species from synonymy, nor did they provide any distinguishing features. We here return *gastrosticta* to the synonymy of *quoyii*.

Diagnosis

A large water skink (adults reaching over 110 mm snout–vent) with sharply-defined narrow pale yellow dorsolateral stripes but without a black vertebral stripe.

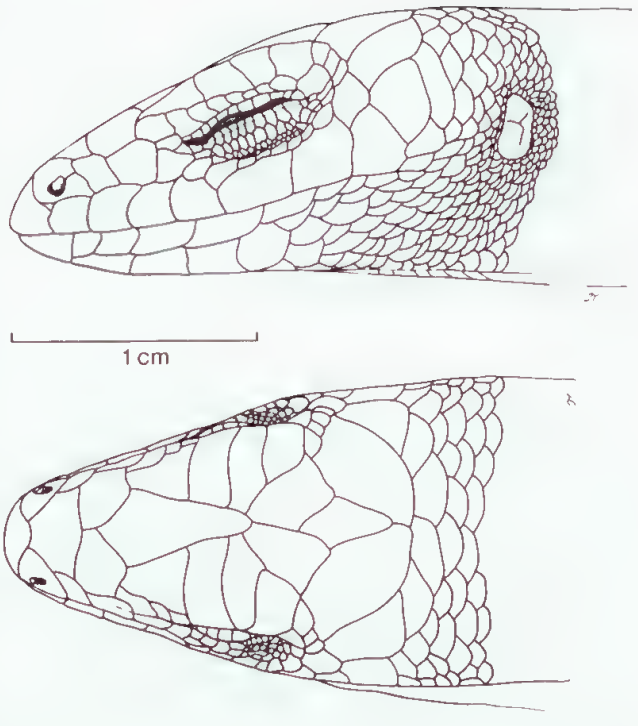

FIGURE 3. Head shields of *Eulamprus quoyii* (SAM R33009).

Description

36–42 ($\bar{x}$ 39.3, n = 36) longitudinal scale rows at midbody. Paravertebral scales 74–88 ($\bar{x}$ 79.7, n = 36), no larger or only slightly broader than adjacent dorsals. Subdigital laellae on fourth toe 24–32 ($\bar{x}$ 27.4, n = 35), most with a median groove and those at the base of the toe divided.

Prefrontals usually broadly contacting (narrowly separated in 4 out of 36). Interparietal elongate, approximately one and a half times as long as wide, but never separating parietals. Each parietal bordered posteriorly by one to three nuchal scales and laterally by the upper secondary temporal. Supraciliaries 9–12 ($\bar{x}$ 9.7, mode 9); first to third or fourth forming decreasing series, next three to five smallest, last two larger, usually penetrating dorsally each side of the fourth supraocular. Supralabials 7–8 (mode 7), fifth or sixth subocular. Infralabials 7–10 (modes 8 and 9), first and second always and third sometimes in contact with (single) postmental.

Premaxillary teeth usually 9 (n = 9); single specimens each with 7 and 8.

Dimensions (of adults, n = 32). SVL 82–112 mm ($\bar{x}$ 94.9 mm). HW 11.2–17.2 mm. HL 17.3–24.9 mm. HL/HW 1.36–1.68, ($\bar{x}$ 1.53). HW/SVL 0.118–0.177 ($\bar{x}$ 0.146). HLL 31–43 mm. HLL/

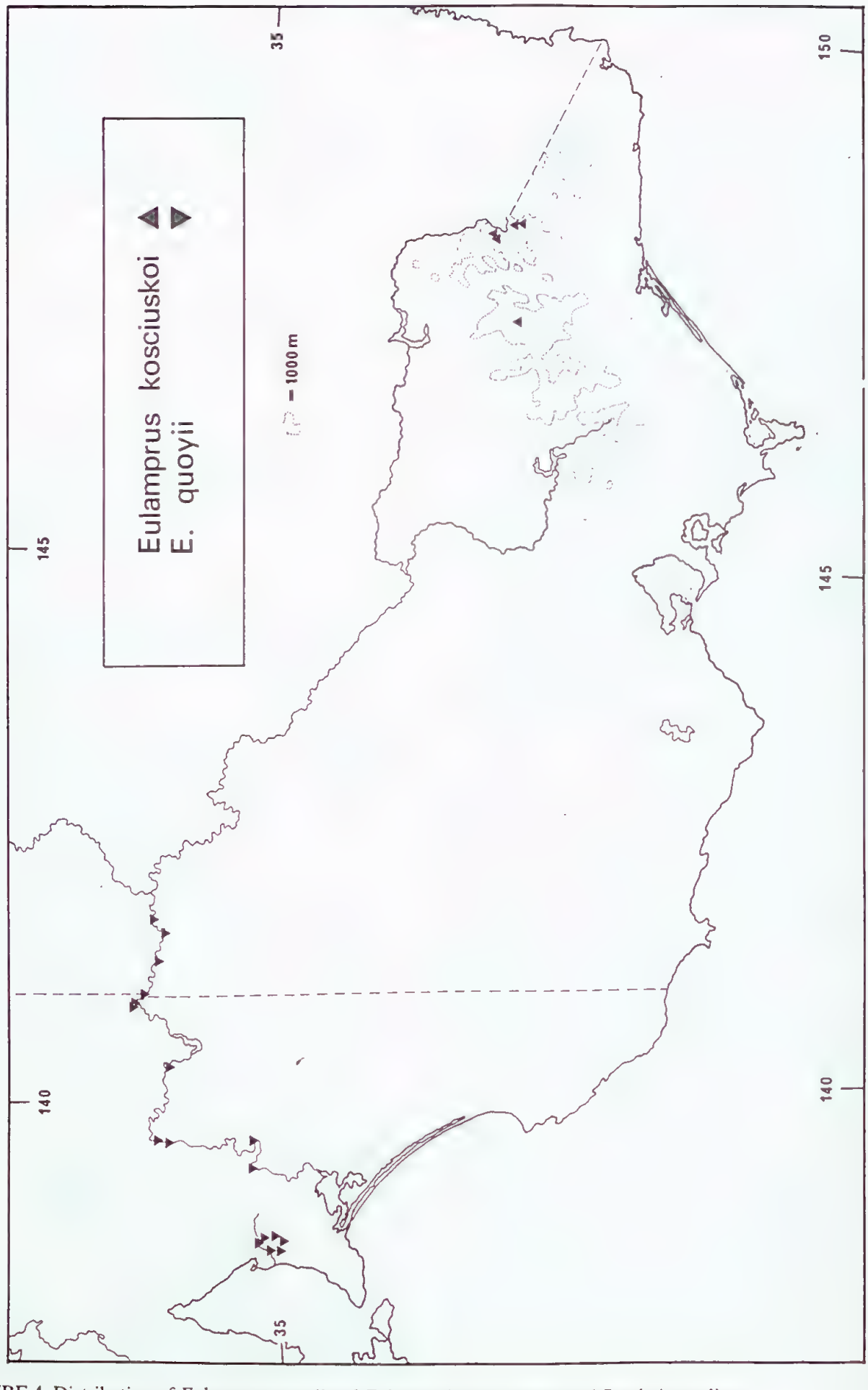

FIGURE 4. Distribution of *Eulamprus quoyii* and *E. kosciuskoi* in Victoria and South Australia.

SVL 0.333–0.464 ($\bar{x}$ 0.401). Tail length/SVL (n = 8) 1.71–1.89 ($\bar{x}$ 1.80).

Colour (in preservative) light to medium brown on the dorsal surface of the head, body, tail and limbs. Dorsum of head and body with a few irregularly scattered flecks. Limbs brown with irregular black bars. A narrow, well-defined pale yellow dorsolateral stripe runs from the supraciliaries posteriorly to half way along the back, whence it breaks up and fades before reaching the hips. This stripe often margined medially by a narrow black line. Upper lateral zone black, the colour extending anteriorly to the ear opening. Two to three uneven series of pale dots (each covering one to two scales) overlie the black. Temporals and posterior supralabials usually obscurely spotted with darker pigment. Lower lateral zone greyish-yellow with black flecks tending to align along scale rows to form weak barring. In adults of both sexes infralabials, chin shields and throat pale to dark grey, spotted with cream, the spotting smaller and arranged in longitudinal lines on the throat. Juveniles and subadults lack this pattern, having instead uniform greyish-yellow throat colouring. Underside yellowish white with fine black dots.

In life the colour is similar to that in preservative.

Distribution

The Murray River from its junction with the Darling downstream to about Tailem Bend, South Australia (Fig. 4). A disjunct population occurs in the Mt Lofty Ranges. Extralimitally the species occurs along the Darling River and along the east coast of Australia from Cairns, Qld, south to about Jervis Bay, New South Wales.

Ecology

Eulamprus quoyii is only found adjacent to water, living beside permanent lakes, swamps and billabongs or on the banks of perennial streams, typically being observed on logs or rocks emerging from the water's edge. It appears to have colonised this part of its range by expansion over the Great Divide into the headwaters of the Darling system, and along its course to the Murray. This species thus extends into a climatically unsuitable (arid) environment by restricting its activity to the mesic riparian corridors (Littlejohn & Rawlinson 1971).

Aspects of the ecology of *E. quoyii* have been examined by Veron (1969), Spellerberg (1972b–d), Daniels (1987) and Daniels & Heatwole (1984, 1990), all studies relating to humid, warm temperate, east coastal populations.

Females ovulate late October–November, with litter size (oviducal eggs) ranging 2–5 ($\bar{x}$ 4.0, n = 5) in Murray Valley and Adelaide Hills specimens. Testes are enlarged between April and August, and regress over spring to a minimum in November–January. The species is viviparous, the young being born during January and February. Mating has been recorded by Veron (1969) as occurring in spring.

Discussion

This species is the type of Fitzinger's genus *Eulamprus*, and Gray's *Hinulia* (Mittleman, 1952), and featured in several early studies of lizard anatomy (Siebenrock, 1892, 1895, Busch 1898). More recently it has been subjected to a variety of anatomical and physiological studies (King 1964, Daniels 1985, Daniels, Heatwole & Oakes 1987, Daniels, Oakes & Heatwole 1987).

Eulamprus quoyii is much the largest of the species in the *E. quoyii* complex, with a mean adult SVL of 95 mm and a maximum of 118 mm (extralimitally), both values being roughly 15 mm greater than the corresponding values for the next largest species (*E. heatwolei* and *E. tympanum*). It shares with *E. heatwolei* the most gracile proportions seen in the group, with the longest extremities and slenderest head.

Distribution in the area considered is limited to the Murray River valley and three west-flowing river systems (Torrens, Sturt and Onkaparinga) of the adjacent Mt Lofty watershed. The grey and cream mottled throat pattern is more weakly developed in Mt Lofty populations compared with the Murray Valley populations, suggesting slight differentiation of the two. In this feature, the Mt Lofty populations are more similar to the east coast New South Wales populations in which throat patterning is also weakly developed or absent.

Eulamprus tympanum tympanum (Lönnberg & Andersson, 1913)

(Figs 1, 5)

Lygosoma tympanum Lönnberg & Andersson, 1913: 9. Holotype: NHRM 3094 'neighbourhood of Melbourne', Victoria.

Sphenomorphus quoyii tympanum (part) Loveridge, 1934: 350.

Sphenomorphus tympanus Mittleman, 1952: 31.

Sphenomorphus tympanum (part) Worrell, 1963: 53.

Sphenomorphus tympanum Cool Temperate Form, Rawlinson, 1969: 119.

Eulamprus tympanum Wells & Wellington, 1984: 94.

Eulamprus herseyi Wells & Wellington, 1985: 29. Holotype: AMS R111949 (formerly AM Field Series 16791), Dora Dora National Park Proposal Area near Albury, New South Wales.

Type Specimens

The holotype of *Lygosoma tympanum*, NHRM 3094, is in good condition and clearly identifiable as belonging to the 'Cool Temperate Form' of Rawlinson (1969). The anterior margin of the ear opening is pale, the throat and chin are smudged with grey and there is no trace of a pale post-supraciliary streak. Midbody scales are in 37 rows. The specimen is immature, with a SVL of 46 mm. The appearance of the specimen is consistent with the collection data–'said to have been collected in the neighbourhood of Melbourne, July 1911'.

Wells & Wellington (1985) failed to differentiate *Eulamprus herseyi* from its congeners. Their purported diagnosis merely listed a number of scalation and meristic parameters none of which, either individually or collectively, differentiates *E. herseyi* from *E. heatwolei, E. tympanum* or even *E. quoyii*. The only exception is the supposed five supraoculars. The holotype does have five supraoculars on the right side due to an abnormally divided first supraocular but the normal count of four is present on the left side and the specimen is otherwise a typical *E. tympanum*. Wells & Wellington define their genus *Eulamprus* (restricted to the *quoyii* complex) as having four supraoculars, although two of the three species they described, *E. heatwolei* and *E. herseyi*, were said to have five. Possibly the small scale at the posterior end of the supraoculars (see above, p. 187) is responsible for this inconsistency.

Diagnosis

A water skink lacking any trace of longitudinal dorsal striped pattern, with a pale anterior margin to the ear opening, usually 42 or fewer midbody scale rows and without transversely oriented dark dorsal markings.

Description

36–44 ($\bar{x}$ 39.2, n = 116) longitudinal scale rows at midbody. Paravertebral scales 68–89 ($\bar{x}$ 75.3, n = 116), scarcely broader than adjacent dorsals. Subdigital lamellae on fourth toe 18–29 ($\bar{x}$ 22.4, n = 109), most with a median groove and those at the base of the toe divided.

Prefrontals separated (freq. 0.45) or in point to moderately broad contact. Interparietal elongate, approximately twice as long as wide, but usually not separating parietals (frequency of separation 0.11). Each parietal bordered posteriorly by one to three nuchal scales and laterally by the upper secondary temporal. Supraciliaries 8–10 (> 3 > rest. Supralabials 6–9 ($\bar{x}$ 7.1, mode 7, n = 40), fourth, fifth or sixth subocular. Infralabials 6–9 ($\bar{x}$ 7.5, mode 7, n = 40), first and second in contact with (single) postmental.

Premaxillary teeth usually 8 (n = 9), less often 9 (n = 4) or 7 (n = 1).

Dimensions (adults, n = 90). SVL 66–93 mm ($\bar{x}$ 81.7). HW 10.0–14.6 mm. HL 14.7–19.9 mm. HL/HW 1.27–1.59 ($\bar{x}$ 1.43). HW/SVL 0.137–0.168 (x 0.151). HLL 26–36 mm. HLL/SVL 0.311–0.449 ($\bar{x}$ 0.379). Tail length/SVL (n = 26) 1.40–1.83, $\bar{x}$ 1.58.

Colour (in preservative) light to very dark brown on the dorsal surface of the head, body, tail and limbs, immaculate or with few to numerous irregular black flecks. No suggestion of a pale dorsolateral stripe. Tail with dark flecks better developed laterally than dorsally; limbs overlain by heavy black network. Upper lateral zone black, the colour usually fading to brown on the temples. Several uneven series of widely spaced pale dots (each covering only a single scale) overlie the black. A pale horizontal streak runs posteriorly from the dorsal rim of the ear opening and is continuous with the pale anterior edge of ear opening. Lower lateral zone pale grey, lightly dotted with pale yellow and dark grey, less often with weak black barring. Chin and throat light to dark grey in most populations, sometimes with darker smudges. Otway Ranges specimens sometimes with black throats. Remainder of underside yellowish white, sometimes immaculate but usually with black markings which may occur as small dark flecks or as black pigment concentrated along the edges of scale rows, forming thin lines.

In life the general colour is similar in most populations. Ventral colour of Otway Ranges specimens usually bright yellow.

Distribution

The Great Dividing Range, continuous from the New South Wales border to about Ballarat, extending south from the Divide into southern Gippsland. Disjunct populations occur around the Pyrenees, Grampians and Otway Ranges and far southwestern Victoria and southeastern South

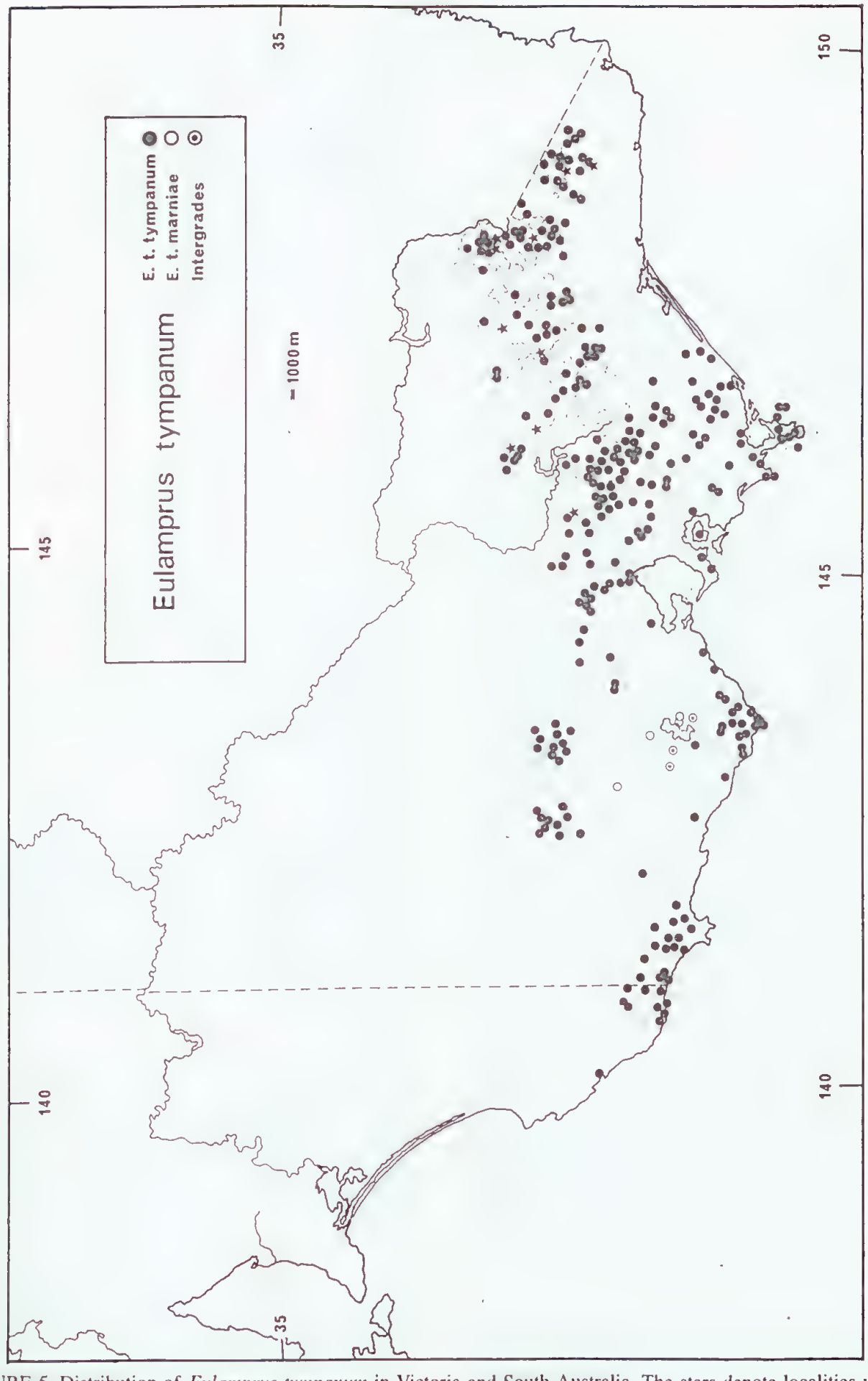

FIGURE 5. Distribution of *Eulamprus tympanum* in Victoria and South Australia. The stars denote localities where *E. heatwolei* and *E. t. tympanum* have been collected in syntopy.

Australia (Fig. 5). Extralimitally the species extends northward along the Great Dividing Range as far as the Blue Mountains, west of Sydney, New South Wales.

Ecology

Aspects of the ecology of *E. t. tympanum* have been covered by Rawlinson (1969, 1971, 1974), Spellerberg (1972b–d), Pengilley (1972), Tilley (1986), Brown (1991) and Schwarzkopf (1992). It is a diurnal and heliothermic skink, restricted to the margins of water courses only in the lower rainfall portions of its range (e.g. the northern and western margins of Melbourne). Over much of cool temperate southeastern Australia, *E. t. tympanum* is a widespread forest-dwelling species. In montane forests in eastern Victoria, the Australian Capital Territory and southern NSW this is one of the most commonly encountered reptile species. Activity is generally centred around rotting fallen logs and stumps which are used as perches for thermoregulation and the cavities of which are used for shelter (Mather 1978, Tilley 1986). Tilley's study demonstrated that the species is probably non-territorial, has low juvenile survivorship but potentially long-lived adults, females living for up to 13 years and males to 11. Brown (1991) found that this species is a generalised invertebrate carnivore, taking only a small proportion of plant matter in its diet.

Females ovulate late October–November, with litter size (oviducal eggs) ranging 2–6 ($\bar{x}$ 4.5, n = 16). Testes are enlarged between April and August, and regress over spring to a minimum in November–January. The species is viviparous, the young being born during January and February. The time of mating has not been recorded. Rawlinson (1974) stated that *E. tympanum* mated in autumn, with overwintering of sperm by females. This latter conclusion was drawn directly from the above mentioned observations of the testicular cycle coupled with the belief that testicular enlargement ought to be correlated with male sexual activity. However, as Greer (1989) noted, both *E. quoyii* (Veron 1969) and *E. heatwolei* (Pengilley 1972) are known to mate in spring even though, like *E. tympanum*, they have a testicular maximum in late autumn–winter. Observational data are needed to establish the time of mating for *E. tympanum*.

Discussion

Eulamprus tympanum is most obviously different from the other water skinks in having a broader head relative to body size than the other species. In body and limb proportions it is intermediate between the gracile *E. quoyii* and *E. heatwolei* and the dumpy *E. kosciuskoi*.

The nominate subspecies shows little geographic variation even though several western populations appear to be isolated from one another. Local trends include larger scales and a greater development of linear black ventral markings in Otway Ranges specimens and longer tails and smaller body scales in Grampians specimens. A general trend is for rock-dwelling, streamside populations to have a greater development of black dorsal flecking than log-dwelling, forest populations.

Eulamprus tympanum marnieae subsp. nov.

(Figs 5–7)

Eulamprus tympanum ssp. nov. Cogger *et al.* 1993: 107.

Types

HOLOTYPE: NMV D52921, adult male, 5.5 km E. of Dreeite, Victoria, 38°11'S, 143°34'E, P. A. Rawlinson; P. Robertson and M. Hutchinson, 1 November, 1979.

PARATYPES: 30 specimens, all from Dreeite area. D49377, D49385–92, D52912–20, D52922–52926, D52955–56, D53977–80, D62035 (see appendix for details of localities).

Diagnosis

A water skink distinguished from all other members of the *E. quoyii* species complex by the very small midbody scales (usually in 43 or more rows, versus usually 42 or fewer), the black dorsal markings arranged as short irregular transverse bars, and bold ventral pattern of black longitudinal bars on a bright yellow (in life) background.

Description

40–48 ($\bar{x}$ 44.8, n = 36) longitudinal scale rows at midbody. Paravertebral scales 76–95 ($\bar{x}$ 84.4, n = 36), no larger or only slightly broader than adjacent dorsals. Subdigital lamellae on fourth toe 20–26 ($\bar{x}$ 22.9, n = 36), most with a median groove and those at the base of the toe divided.

Prefrontals separated (freq. 0.47) or in point to moderately broad contact. Interparietal elongate, approximately twice as long as wide, and almost or actually (0.19) separating parietals. Each parietal bordered posteriorly by one to three nuchal scales and laterally by the upper secondary temporal. Supraciliaries 7–9 ($\bar{x}$ 8.0); first to third forming decreasing series, next three smalles, last two larger, usually penetrating dorsally each side

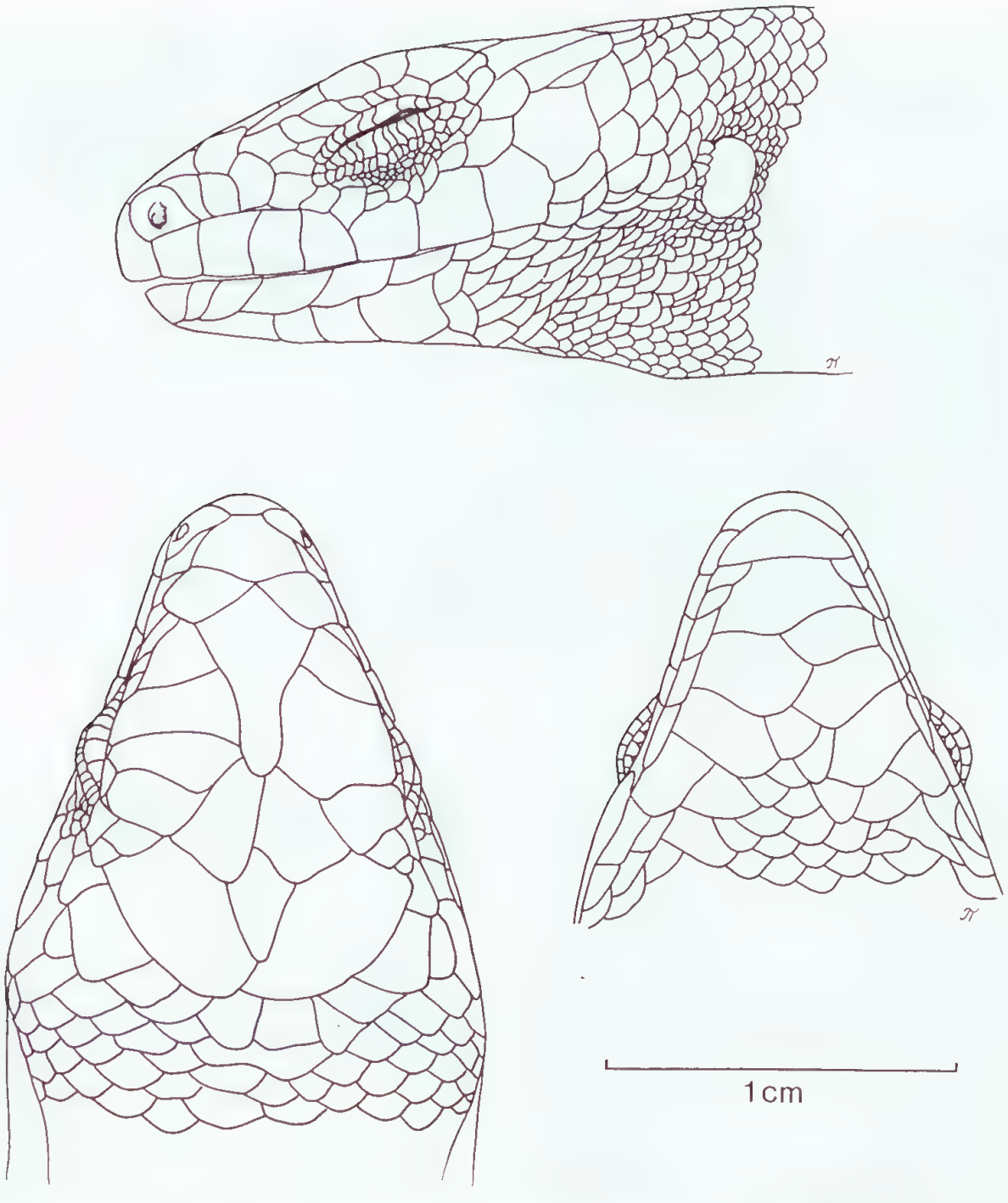

FIGURE 6. Head shields of the holotype of *Eulamprus tympanum marnieae* n. subsp. (NMV D52921).

of the fourth supraocular. Supralabials 6–8, fifth or sixth subocular. Last supralabial sometimes horizontally divided (n = 2) to give the count of six. Infralabials 7–9, first and second in contact with (single) postmental.

Premaxillary teeth 8 (n = 3).

Dimensions (adults, n = 27). SVL 72–97 mm. HW 10.4–15.7 mm. HL 15.3–20.6 mm. HL/HW 1.32–1.50 ($\bar{x}$ 141). HW/SVL 0.132–0.171 ($\bar{x}$ 0.141). HLL 27–36 mm. HLL/SVL 0.323–0.420 ($\bar{x}$ 0.368). Tail length/SVL (n = 6) 1.52–1.72 ($\bar{x}$ 1.63).

Colour (in preservative) light to very dark brown on the dorsal surface of the head, body, tail and limbs, overlain by black markings as follows: head shields with irregularly scattered flecks; back with numerous irregular patches, generally laterally expanded to form transverse bars, some contacting the black upper lateral zone; tail with closely-spaced transverse wavy bars better developed laterally than dorsally; limbs overlain by heavy black network. Upper lateral zone black, the colour extending anteriorly to the eyes. One or two uneven series of widely spaced pale dots

FIGURE 7. Live paratype female of *Eulamprus tympanum marnieae* (NMV D53980) (photo: M. Hutchinson).

(each covering two or three scales) overlie the black, including a whitish temporal spot and a horizontal streak running posteriorly from the dorsal rim of the ear opening and continuous with its pale anterior edge. Dorsal margin of upper lateral black colouring with jagged projections, with a pale spot in the notches between the projections. Lower lateral zone greyish yellow with irregular black barring. Anteriorly to the axilla, the lower lateral zone resolves itself into a midlateral pale stripe. Chin shields white spotted with black. Throat grey-white with large blackish patches laterally which form the ventral margin of the midlateral pale stripe. Underside yellowish white with black pigment forming interrupted longitudinal black patches.

In life the general colour is similar but suffused with yellowish. The dorsal ground colour is frequently bright brassy and the underside of the belly, limbs and tail is bright yellow.

Features of Holotype

Midbody scale rows 47. Paravertebral scales 78. Subdigital lamellae under fourth toe 23. Supralabials 7/8. Infralabials 7/8. Supraciliaries 7/7. Anomalies of scalation include a supernumerary anterior chin shield on the left side and three loreals also on the left side. SVL 80 mm. Tail length 133 mm (1.66 SVL). HLL 33 mm (0.413 SVL). HW 13.0 mm (0.163 SVL). HL 18.0 mm. HL/HW 1.38. Testes regressing.

Etymology

Named for Marnie Lincoln Rawlinson.

Distribution

Rocky outcrops and drystone walls on the northern margins of the basaltic 'stony rises' east and north of Lake Corangamite, southwestern Victoria (Fig. 5). An outlying population occurs beside Lake Bolac to the northwest.

Ecology

A diurnal, evidently heliothermic skink, normally observed perched on a rockpile or fence. Unlike other water skinks this is an extremely shy lizard, fleeing to cover even when a human observer is tens of metres distant and seldom coming into open view while being watched. Like other water skinks, *E. t. marnieae* will dive into water and swim submerged to escape pursuit, but most individuals are observed away from standing water and take refuge in deep gaps in rockpiles. Favoured localities combine remnant arboreal vegetation (notably *Hymenanthera*, Violaceae), deeply fissured basaltic rock piles and permanent or ephemeral swamps. Its habitat in summer can appear very arid compared with the areas

inhabited by its relatives, but in winter the terrain is extensively flooded, with almost all depressions and low-lying areas holding water, and it seems likely that the deep rock piles favoured by this subspecies provide cool and humid refuges even during the dry summer months.

Specimens have been collected between the end of winter and mid-summer and in late autumn. Females ovulate late October–early November, with recorded litter size (oviducal eggs) ranging 2–6 ($\bar{x}$ 4.3, n = 21). Males with enlarged testes have been collected in April and September, with testes regressing in October–November and completely regressed in January. Viviparity is the mode of reproduction in all other water skinks for which mode is known (not confirmed for *E. leuraensis*) so it is highly probable that *E. t. marnieae* is also viviparous. Birth would be expected to occur in January, reinforced by the collection date of the smallest individual in the series, a juvenile (D53977, SVL 39 mm) collected on 24–25 January.

Discussion

The subspecies is known from three populations, each slightly differentiated (see Table 1). Aside from the type population described above, series have been collected from 8 km S of Lismore, Vic., (NMV D36075–084) and from Lake Bolac (D52600–01, D52901–09). The Lismore series is notable for its higher paravertebral counts (up to 98), high frequency of separation of the parietals by the interparietal (8 out of 10) and for a relatively high incidence of division of the last supralabial (4 out of 10). The Lake Bolac specimens are darker, with less yellow pigmentation in life, have the highest midbody scale counts (up to 53), high frequency of separated parietals (7 out of 11) and a common scalation abnormality, fusion of the last two supralabials (5 out of 11).

This taxon is readily distinguished from other water skinks by its small scales and bold dorsal pattern, and the initial conclusion on discovering this form was that it represented a new species. However, subsequent collections suggest that it intergrades with typical *E. tympanum*. North and west, relatively arid conditions provide a barrier between the two; no water skinks have been found in the arc running from between Lake Bolac and the Pyrenees east to about Rokewood and southeast to about Winchelsea. However, to the south and southwest, typical *E. tympanum* is more continuously distributed and specimens from Cororooke (south of Dreeite) and from north of Camperdown (Kariah and Lake Colongulac) are intermediate in colour pattern and scalation between typical *tympanum* and *marnieae* (Table 1).

Such populations have become taxonomically problematic with the recent acceptance of the inadequacy of the old subspecies concept (Collins 1992, Frost *et al.* 1992). The overuse of 'subspecies' to arbitrarily name geographically isolated but undifferentiated populations or to artificially partition continuous or clinal variation has devalued the term, but there remain cases such as the present in which a relatively consistent phenotype confined to a specified geographic area appears to be genetically continuous with adjacent

TABLE 1. Comparison of Victorian populations of *Eulamprus tympanum*. Colour pattern characters scored are: **1**, black transverse dorsal bars present; **2**, black longitudinal ventral bars present; **3**, lateral margins of throat black; **4**, pale lateral flecks cover more than a single scale.

Population (n)	MBSR (x)	PVS (x)	Colour pattern characters 1	2	3	4
E. t. marnieae						
Dreeite area (36)	44.8	84.4	+	+	+	+
8 km S of Lismore (10)	48.4	92.9	+	+	+	+
Lake Bolac (11)	51.1	85.0	+	+	+	+
Intermediate						
Camperdown area (5)	41.0	79.6	–	+	+	–
Cororooke (3)	40.7	77.3	+/–	+	+	–
E. t. tympanum						
Pirron Yallock (2)	39.0	80.0	–	–	–/+	–
Otway Ranges (30)	37.5	73.1	–	–/+	–/+	–
Grampians (30)	40.7	77.0	–	–	–/+	–
Pyrenees–Mt Macedon (26)	39.5	76.8	–	–	–	–
Eastern Victoria (30)	39.3	74.6	–	–	–	–

but phenotypically and geographically discrete populations (Frost & Hillis 1990). In the case of the water skinks reticulate evolution probably occurs at least on the southern margins of the distribution of *marnieae*. The possibility exists of introgression of genes beyond the limits of any putative hybrid zone, suggested by an increase in midbody scale counts south to north moving away from the contact with *tympanum*. To combine the two simply as a binomial *E. tympanum* would bury this most distinctive population, while to recognise *marnieae* as a full species would be to imply an evolutionary independence which is denied by the circumstantial evidence available. Further specimens and biochemical genetic data would illuminate the degree of gene flow currently occurring and would reveal the degree to which the intermediate populations are acting as a bridge or barrier to gene flow; should the latter be established, elevation of *marnieae* to full species status would logically follow. The fact is, however, that such data will be difficult to obtain due to the general difficulty of locating any water skinks in the highly modified intergrade areas.

Eulamprus t. marnieae inhabits a geographically peculiar Victorian landform, technically part of the Newer Volcanics, a region of extensive late Tertiary sheet basalt lava flows, and colloquially known as the 'stony rises'. The 'rises' are basalt ridges and boulder heaps left by the collapse of lava tunnels. The area supports other distinctive herpetofauna, including a small-scaled, speckled form of *Pseudemoia entrecasteauxii* (Hutchinson & Donnellan 1992) and a green morph of the normally brown treefrog, *Litoria ewingii* (Hero *et al.* 1991).

Within its limited geographic range this subspecies occurs only patchily, with only one large colony known. Most of the area in which the species probably once occurred has been extensively modified, with total clearing of vegetation for grazing and continuing demolition of drystone walls and removal of boulders for 'mossy rock' landscape gardening. These processes show no signs of ceasing and the subspecies must be regarded as threatened. The Lismore population was probably wiped out during the rock clearing activities that produced the specimens.

Eulamprus kosciuskoi (Kinghorn, 1932)
(Figs 4, 8)

Lygosoma (Hinulia) quoyii kosciuskoi Kinghorn, 1932: 359. Holotype: AMS R4654, Mt Kosciusko, New South Wales.

Sphenomorphus quoyii tympanum (part) Loveridge, 1934: 350.

Sphenomorphus kosciuskoi Mittleman, 1952: 26.

Sphenomorphus tympanum (part) Worrell, 1963: 53.

Eulamprus kosciuskoi Wells & Wellington, 1984: 93.

Types

The specimens forming the type series, a holotype, AMS R4654, and four paratypes (AMS R558–9, R4832 and R5061), are clearly identifiable as belonging to the southern population. They have a light colour pattern, with weakly marked head and clear light ground colour between the black vertebral and dorsolateral stripes. The dark upper lateral zone does not extend to the ventrolateral area. Midbody scales are in 31–34 rows[2]. The holotype has 34 midbody scale rows, 19 subdigital lamellae and a SVL of 76 mm.

Diagnosis

A small water skink (largest adult 86 mm snout-vent) distinguished from all but *E. leuraensis* by the presence of a black vertebral stripe. Said to differ from *E. leuraensis* by its paler dorsal colouring (including weakly marked head), broader paravertebral stripes and pale-spotted black lateral pattern stopping at the midlateral level rather than extending to the ventrolateral angle of the trunk (Shea & Peterson, 1985).

Description

30–34 ($\bar{x}$ 32.3, n = 37) longitudinal scale rows at midbody. Paravertebral scales 58–68 ($\bar{x}$ 63.6, n = 32), slightly broader than adjacent dorsals. Subdigital lamellae on fourth toe 18–23 ($\bar{x}$ 20.5, n = 32), most with a median groove and those at the base of the toe divided.

Prefrontals moderately separated to broadly contacting (frequency of separated prefrontals 0.38); an azygous 'interprefrontal' sometimes present (frequency 0.16). Interparietal elongate, approximately twice as long as wide, usually (frequency 0.71) separating parietals. Each parietal bordered posteriorly by two moderately

[2] Shea & Peterson (1985) gave the range for this series as 32–35, but obtained the same average across all five, 32.2, as we did.

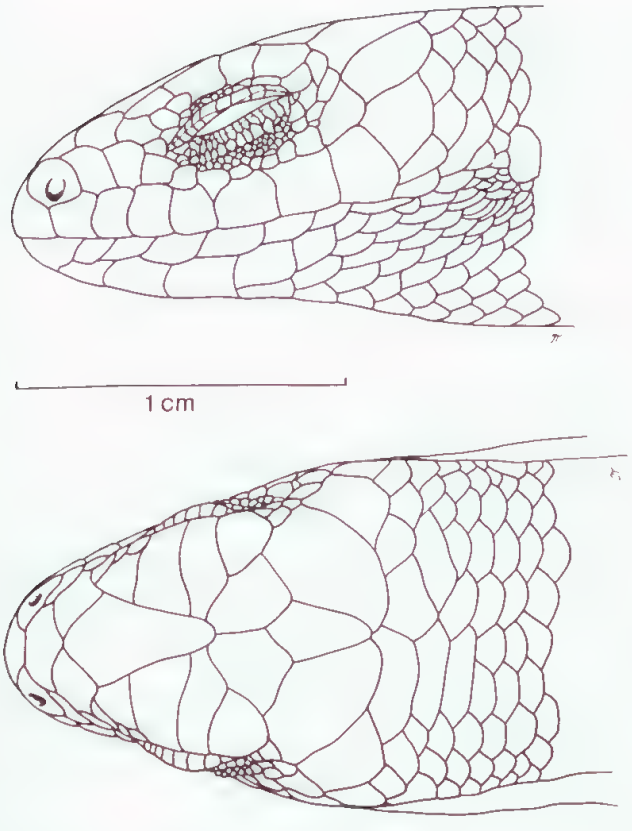

FIGURE 8. Head shields of *Eulamprus kosciuskoi* (NMV D42202).

expanded nuchal scales and laterally by a large upper secondary temporal. Supraciliaries 7–9; size 1 > 2 = last > 3 > rest. Supralabials 6–7 (mode 7), fourth or fifth subocular. Infralabials 7–8 (mode 7), first and second in contact with (single) postmental.

Premaxillary teeth 8 (n = 2) or 9 (n = 2).

Dimensions (of adults, all females, n = 13). SVL 66–74 mm ($\bar{x}$ 70.6). HW 9.2–10.9 mm. HL 13.8–15.4 mm. HL/HW 1.40–159 ($\bar{x}$ 1.49). HW/SVL 0.129–0.152 ($\bar{x}$ 0.140). HLL/SVL 0.292–0.361 ($\bar{x}$ 0.326). Tail length/SVL (for individuals > 50 mm SVL, n = 8) 1.07–1.25 ($\bar{x}$ 1.17).

Colour (in preservative) light brown on the dorsal surface of the head, body, tail and limbs. Back with a black vertebral stripe running from the nape to the base of the tail. A narrow yellow dorsolateral stripe runs from the supraciliary region to the base of the tail, becoming less brightly coloured. This stripe edged medially by a wider black stripe. Black upper lateral zone, commencing at the ear and breaking up on the tail, with three to four series of yellowish dashes or dots, tending to align longitudinally on adjacent scale pairs. A horizontal streak runs posteriorly from the top of the ear opening and is continuous with the pale anterior margin of the ear. Tail with regularly spaced blackish lateral blotches. Limbs brown mottled with black. Lower lateral zone greyish with black spots, the pattern continuing across the belly. Infralabials, chin, throat and remainder of underside greyish white with scattered black spots.

In life the general colour is similar but overlain by a yellow–green opalescent gloss.

Distribution

Davies Plains–Mt Cobberras area and the Bogong High Plains, Victoria (Fig. 4). The southern, typical populations of this species are confined to the Snowy Mountains of New South Wales and the adjacent alpine areas of Victoria. A second morphologically distinct group of populations occurs in the Barrington Tops region and on the New England Plateau (Shea & Peterson, 1985).

Ecology

The Snowy Mountains–Victorian High Plains populations of this species have a restricted habitat, being found only in subalpine to alpine bogs and sluggish creek margins, the habitats being characterised by being perennially wet, cool and densely vegetated at ground level. Coventry & Robertson (1980) and Mansergh (1982) briefly describe the habitat of this species at Davies Plains and Mt Cope, respectively.

We have no explanation for the absence of males in this sample, and their under-representation in the samples of *E. heatwolei* and *E. tympanum*. Certainly those females that are pregnant are more catchable than non-pregnant females or males, but excluding pregnant females still leaves a deficiency of males. Further study of wild populations could determine whether there is a sex ratio bias against males, or whether behavioural attributes of the sexes make males harder to collect.

Most specimens have been collected during late January, at which time about half of the females (5) have full term young, while the rest (6) contain no young or enlarged ova. A single adult female collected in December contains advanced embryos, while a single adult female collected in February is non-breeding. At present it is not possible to say whether the females without young in January had just given birth or had not bred that year, but this would be worth exploring in view of the fact that females of the Tasmanian alpine skinks (*Niveoscincus*) only breed every second year (Greer, 1982, Hutchinson *et al.* 1989). Litter size is 2–4 ($\bar{x}$ 3.2).

Discussion

Shea & Peterson (1985) noted that the topotypic (Mt Kosciusko area) population of *E. kosciuskoi* is more similar to *E. leuraensis* than is the New England population, suggesting some intermediacy, but maintained the specific distinctness of the latter taxon. In fact, where one draws the line between populations depends upon the character chosen; if colour pattern, then most Snowy Mountain–Victorian and New England *E. kosciuskoi* are more similar to each other than either is to *E. leuraensis*, while if limb proportions and head and body scalation are considered, then the new England *E. kosciuskoi* stand apart. Moreover, the more melanised individuals in the Victorian sample approach the description of *E. leuraensis* in that the head is heavily black-flecked, the laterodorsal black stripes are broader and leave little dorsal ground colour showing and the midlateral pattern extends ventrally to the lower lateral area. It appears therefore that no absolute distinctions separate any populations formerly referred to *E. kosciuskoi*. It is evident from comparison with other water skink populations that degree of dorsal melanisation can be labile in water skinks and that isolated populations can undergo shifts in scale count frequencies. The situation of *E. tympanum* discussed above also shows that much greater qualitative differences in colour pattern and scale size are not necessarily indicative of independently evolving entities (species).

Allopatric populations are a problematic group, even if one discards the increasingly unpopular biological species concept (BSC, e.g. Frost & Hillis 1990). Recent debate on the North American fauna (Collins 1991, 1992, Montanucci 1992, Van Devender *et al.* 1992, Frost *et al.* 1992) highlights the differing views that can exist concerning populations which until recently most authors would have identified as subspecies, more for convenience than as a positive expression of the degree of historical independence. Further consideration of the status of *E. leuraensis* is beyond the scope of this study, but the appropriate taxonomic treatment for the alpine water skink populations could stand further analysis.

Eulamprus heatwolei Wells & Wellington, 1984

(Figs 9, 10)

Sphenomorphus tympanum Warm Temperate Form, Rawlinson, 1969: 119.

Eulamprus heatwolei Wells & Wellington, 1984: 93. Holotype: AMS R116967 (formerly AM Field Series 27987), Macquarie Rivulet, just east of Robertson, New South Wales, R. W. Wells, 20 October, 1982.

Sphenomorphus heatwolei Shea & Peterson, 1985: p. 144.

Type Specimen

The holotype of *Eulamprus heatwolei*, AMS R116967, is in moderate condition, with the tail almost broken and is clearly identifiable as belonging the 'Warm Temperate Form' of Rawlinson (1969). Wells & Wellington (1984) purported to diagnose the species by listing the attributes of the holotype, but only aspects of the colour pattern description are unique to *heatwolei*. Our observations on the holotype disagree with those of Wells and Wellington (in square brackets) in several significant respects. Midbody scale rows 40 [38]. Tail regenerated, so subcaudal count [73] irrelevant. Supraoculars 4 [5]; first supraocular on left fragmented, with two abnormal small scales contiguous with the supraciliary row. Postnasal scales absent [said to be present]. One [2] preocular, if the lower of two antorbital scales is regarded, as here, as the first presubocular. Supraciliaries 10/9 [6]. Adpressed limbs strongly overlap, the fourth toe of the hind foot reaching about the level of the elbow [adpressed limbs just fail to meet]. Other important points not mentioned in the type description are throat colouring, the chin shields being heavily edged with black and the throat grey with four irregular blackish longitudinal bars, and size, the snout–vent length being 71 mm.

Diagnosis

A water skink lacking longitudinal dorsal stripes, most similar to *E. tympanum*, but differing in its longer appendages, pale post-supraciliary streak, black anterior edge of the tympanic opening and immaculate venter (bright yellow in life).

Description

36–44 ($\bar{x}$ 39.9, n = 73) longitudinal scale rows at midbody. Paravertebral scales 69–89 ($\bar{x}$ 77.5, n = 73), scarcely or not broader than adjacent dorsals. Subdigital lamellae on fourth toe 23–29 ($\bar{x}$ 25.1, n = 73), most with a median groove and those at the base of the toe divided.

Prefrontals in point to broad contact (freq. = 0.32). Interparietal elongate, approximately twice as long as wide, but seldom separating parietals

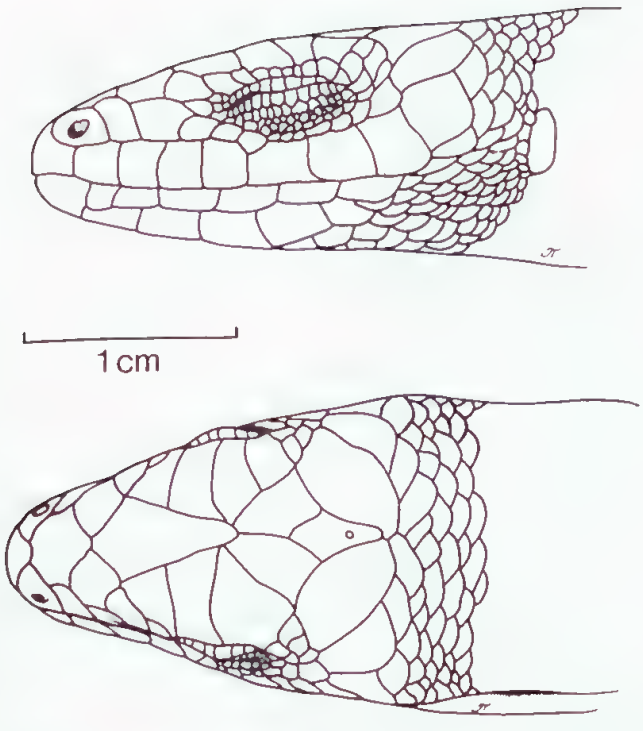

FIGURE 9. Head shields of *Eulamprus heatwolei* (SAM R38610).

(3 out of 73 scored). Each parietal bordered posteriorly by one to three nuchal scales and laterally by the upper secondary temporal. Supraciliaries 7–11 ($\bar{x}$ 9.1, mode 9); size 1 > 2 = last > 3 > rest. Supralabials 7–9 (mode 7), fifth or sixth subocular. Infralabials 6–9 (mode 8), first and second in contact with (single) postmental.

Premaxillary teeth usually 9 (n = 8), less often 8 (n = 3).

Dimensions (of adults, n = 47). SVL 74–101 ($\bar{x}$ 84.3). HW 10.1–14.0 mm. HL 16.3–20.7 mm. HL/HW 1.42–168 ($\bar{x}$ 1.51). HW/SVL 0.126–0.162 ($\bar{x}$ 0.143). HLL 30–36 mm. HLL/SVL 0.327–0.439 ($\bar{x}$ 0.379). Tail length/SVL (n = 13) 1.58–1.92 ($\bar{x}$ 1.76).

Colour (in preservative) light to very dark brown on the dorsal surface of the head, body, tail and limbs. Head shields with irregular black flecks. A paler brown streak, suggesting the start of a pale dorsolateral stripe, runs posteriorly from the supraciliary region to the neck. Back usually with numerous irregular black flecks; immaculate in very few specimens (those from the Murray River, both Victorian and South Australian). Tail with black, closely-spaced wavy bars laterally; limbs overlain by wavy black bars. Upper lateral zone black, the colour extending over the temporals and eye to the loreals. Several uneven series of pale dots (each covering only a single scale) overly the black. A pale horizontal streak runs posteriorly from the dorsal rim of the ear opening; anterior edge of ear opening black. Lower lateral zone greyish with black scales forming irregular vertical or backward-sloping bars or a black reticulum. Chin and throat white, most populations with black edges on chin shields and elongate black blotches on the throat. Remainder of underside yellowish white, immaculate.

In life the general colour is similar but suffused with yellowish. The dorsal ground colour is frequently brassy and the underside of the belly, limbs and tail is bright yellow.

Distribution

Eastern Victoria, west to about the Goulburn River (Fig. 10). Absent from higher elevations along the Great Dividing Range. An isolated record from Great Western (Victoria) and a disjunct group of populations on the lower Fleurieu Peninsula, South Australia, from Deep Creek to the northern shore of Lake Alexandrina. Extralimital in eastern New South Wales north to the New England plateau.

Ecology

This species is very similar in habits to *E. quoyii*, being mostly restricted to creek margins. Most populations of this species favour rocky substrates, but the species does occur along muddy river banks, notably the Murray in north–central Victoria and at its mouth in South Australia. Its reproductive characteristics appear similar to those of *E. quoyii*, with similar ovarian and testicular cycles. Litter size among the specimens examined ranged 2–4 ($\bar{x}$ 3.3, n = 9).

The distributions of *E. heatwolei* and *E. t. tympanum* are complementary to a remarkable degree; although the distributions abut and interdigitate throughout eastern Victoria there are few places (a total of ten) where specimens have been collected in syntopy (indicated by stars in Figs. 5 and 10). Syntopy generally occurs along stream valleys where *E. heatwolei* can extend along the warm valley floor to contact *E. tympanum* populations inhabiting the cooler, elevated valley slopes. In East Gippsland, the aspect of a section of stream channel can determine the species present, with north facing slopes occupied by *E. heatwolei* while south-facing slopes are occupied by *E. t. tympanum*. Meandering watercourses may show an alternation of species (A. J. Coventry, pers. comm.) depending on the degree of shading. No

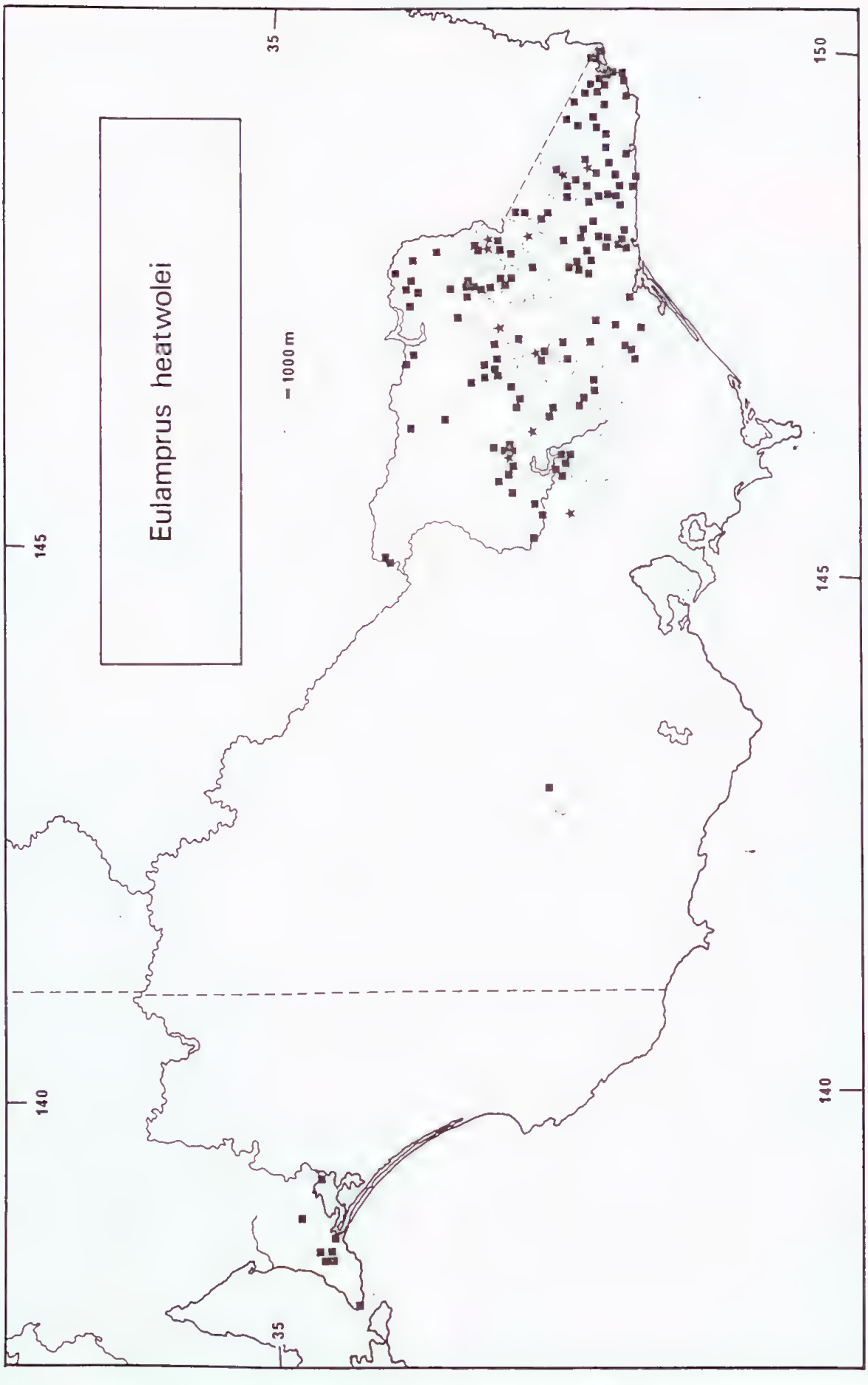

FIGURE 10. Distribution of *Eulamprus heatwolei* in Victoria and South Australia. The stars denote localities where *E. heatwolei* and *E. t. tympanum* have been collected in syntopy.

studies have yet been directed to determining the degree to which competition or the documented physiological differences (Spellerberg, 1972b,c) determine range limits in these two species.

Discussion

The type locality of *E. heatwolei,* Robertson, New South Wales, is adjacent to this region so that as yet the species is not certainly recorded from other parts of Australia. Cogger (1992) mapped the species as far south as the New South Wales-Victoria border. For many years workers have used Rawlinson's informal taxonomy to distinguish two species level taxa, the 'Cool Temperate' and 'Warm Temperate' forms of *Eulamprus* (as *Sphenomorphus*) *tympanum* (e.g. Spellerberg 1972b–d, Rawlinson 1974, Jenkins & Bartell 1980). The forms have been distinguished mainly on ventral colouring, as well as dorsal head colour pattern and proportions. Examination of the holotype of *E. heatwolei* and other New South Wales specimens shows that they do not differ from the Victorian 'Warm Temperate Form'. Accordingly, the concept of *E. heatwolei* is expanded to include these populations.

Shea & Peterson (1985) listed variation within this species based on Blue Mountains area specimens only. Their data are similar to ours, with slightly higher midbody scale counts ($\bar{x}$ 40.8) and maximum snout–vent length a little less (92 mm).

South Australian populations of this species are geographically remote from the main eastern Australian populations, and are restricted to only a few known sites. The terminus of the Murray River on the northern margin of Lake Alexandrina supports a colony living immediately adjacent to the water on eroding banks next to cleared grazing land. On the lower Fleurieu Peninsula *E. heatwolei* is confined to a few perennial rocky streams which retain some streamside vegetation. In spite of their isolation, these populations differ little from the continuous populations of eastern Victoria and New South Wales. Body scales are small, with midbody scale counts restricted to the upper half of the total range of variation seen in the species as a whole (midbody scale rows 40–44, $\bar{x}$ 41.5 in South Australia), and higher paravertebral counts (74–89, $\bar{x}$ 80.2, versus 69–82, $\bar{x}$ 76.4 in Victoria). The South Australian colonies appear vulnerable to habitat changes. At Lake Alexandrina changes in Murray River flow, either decreases leading to drying out or increases causing erosion of the banks, may destroy local populations. In the rocky streams of the Fleurieu Peninsula, modification of the banks, with either clearing of the vegetation or silt build-up reducing exposed rocks, is likely to be deleterious.

A Key To The *Eulamprus* Of Victoria And South Australia

1 – Pale yellow dorsolateral line runs from behind the eye to at least the posterior one-third of the trunk 2

– No pale yellow dorsolateral line 3

2 – A black vertebral stripe ..... *E. kosciuskoi*

– No black vertebral stripe ..... *E. quoyii*

3 – Dark dorsal markings arranged as irregular transverse bars; usually more than 42 midbody scale rows ..... *E. t. marnieae*

– Dark dorsal markings (if present) in the form of small black flecks; usually fewer than 43 midbody scale rows 4

4 – Anterior margin of ear opening black; belly in life immaculate bright yellow, most intense under chest and groin; throat white with black patches ..... *E. heatwolei*

– Anterior margin of ear opening cream; belly in life pale yellow to greenish yellow (bright yellow striped with black in some Otway Ranges specimens) with or without black flecks; throat light to dark grey, with or without darker grey smudges ..... *E. t. tympanum*

Acknowledgments

The Curators of the European collections housing type material showed Peter Rawlinson great hospitality during his tour of collections in 1973, for which he was very grateful. In Australia, R. Sadlier (AMS) and A. J. Coventry (NMV) loaned specimens in their care. MNH particularly thanks Marnie Rawlinson for freely allowing the loan of detailed notes Peter compiled on type material and his unpublished notes on the taxonomy of this lizard group. A. J. Coventry provided encouragement for the project and many useful discussions concerning water skinks and Peter Rawlinson's thoughts on the group. I thank Adrienne Edwards for her help in compiling some of the scale count and morphological data and Jennifer Thurmer (line drawings) and Trevor Peters (photography) for preparation of the illustrations.

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Appendix

Specimens examined.

Eulamprus heatwolei.

New South Wales: AMS R116967, Macquarie Rivulet, just E of Robertson (Holotype).

Victoria: MV D552, Great Western, 37°09'S 142°52'E; D2286, Wangaratta, 36°21'S 146°19'E; D34392, 5.6 km N.E. of Wodonga, 36°10'S 146°51'E; D34488, Nug Nug, Ovens River, 1.6 km. W. of Myrtleford, 36°39'S 146°43'E; D 34541–48, Poddys Creek, 24.1 km. W. of Cann River, 37°36'S 148°54'E; D34549, 14.5 km N. of Nariel, 36°18'S 147°50'E; D 34550, Still Creek, 30.6 km S.E. of Eildon, 37°25'S 146°09'E; D34551, 12.9 km S. of Sardine Creek, 37°31'S 148°40'E; D34552, 16 km E. of Orbost, 37°41'S 148°35'E; D34553, 24.1 km N. of Orbost, 37°34'S 148°34'E; D34554, Snowy River, Tulloch Ard Gorge, 37°16'S 148°19'E; D34560–62, Goulburn River, 16 km S.E. of Seymour, 37°08'S 145°16'E; D36839, Lake Tali Karng, 37°33'S 146°47'E; D36841, 2nd last crossing of Wellington River, Lake Tali Karng Track; D36842, 9.7 km N. of Culloden on Dargo River, 37°41'S 147°08'E; D36843, Wangareta [=Wangaratta], 36°22'S 146°19'E; D36844–45, 14.5 km N. of Stockdale, 37°40'S 147°11'E; D36846–48, 16.1 km N.N.W. of Stockdale, 37°39'S 147°06'E; D36849–53, 5.6 km E. of Wodonga, 36°09'S 146°52'E; D36854–55, 19.3 km S.W. of Walwa, 36°05'S 147°34'E; D36856, 0.4 km. E. of Genoa, 37°28'S 149°36'E; D42564–86, Sheepwash Lagoon, 37°10'S 145°32'E; D56624, Seven Creeks, Goorum Falls, 36°54'S 145°35'E; D57154, Two Mile Creek, 13.4 km N.N.W. of Picolo, 35°59'S 144°56'E; D57164, Ovens River, Naughtons Bend, 14.3 km N.W. of Peechelba, 36°06'S 146°08'E.

South Australia: MV D34467–68, 3.2 km. E. of Myponga; D34487, D36880, Hindmarsh Falls, 35°27'S 138°35'E; D34555–56, D34559, Angas River, Strathalbyn, 35°16'S 138°54'E; D34558, Currency Creek, 35°27'S 138° 46'E. SAMA R2878, Tapanappa Rocks, 35°38'S 138° 15'E; R3018, Deep Creek, 35°36'S 138°15'E; R13436A–B, Withers Creek, tributary of Deep Creek, 35°38'S 138°15'; R17074, 1 km S of Mount Compass, 35°22'S 138°38'E; R18572–73, Tower of Babel, Inman Valley, 35°28'S 138°33'E; R24077, Lake Alexandrina [north shore], 35°24'S 139°19'E; R38557, Hindmarsh Falls, 35°27'S 138°35'E; R38610–12, North shore of Lake Alexandrina at exit of Murray River, Nalpa Stn, 35° 24'S 139° 20'E.

Eulamprus kosciuskoi.

New South Wales: AMS R558–59, R4654, R5061, Mt Kosciusko (Types of *Lygosoma (Hinulia) quoyii kosciuskoi*)

Victoria: MV D42060, Charlies Creek, Davies Plains Track, 36°17'S 147°59'E; D42075, Charlies Creek, Davies Plains Track, 36°17'S 147°59'E; D42110, Charlies Creek, Daveys Plain Track, 36°17'S 147°59'E; D42201–02, Charlies Creek, Davies Plains Track, 36°17'S 147°59'E; D42203, King Plain, Davies Plains Track, 36°39'S 148°04'E; D 47513–15, Davies Plains, 36°17'S 147°59'E; D47539–49, D47589–90, D47654–59, Davies Plains, 36°17'S 147°59'E; D48557, The Playgrounds, Mt. Cobberras, 36°52'S 148°09'E; D55111, Mt. Cope area, 36°56'S 147°17'E; D55630, Rocky Plains, 36°56'S 148°10'E; D56465–66, 1 km E. of Mt. Cope, 36°56'S 147°17'E; D59849, The Playgrounds, Mt. Cobberras, 36°52'S 148°09'E.

Other: AMS R4832, no data ('Tonga', in error).

Eulamprus quoyii.

New South Wales: MNHN 2976, Port Macquarie; 7112–3, Neutral Bay, Port Jackson. (Types of *Gongylus (Lygosoma) quoyii).*

Victoria: MV D1352, D1372, No other data; D13871, Lindsay River, Berribee Station, 34°0'S 141°0'E; D34326–31, Murray River, 6.4 km W. of Lock No.9; D39078–79, Potterwalkalgee Creek, 34°08'S 141°23'E; D39080–81, Murray River & Potwatagee [=Potterwalkalgee] Creek junction, 34°08'S 141°23'E; D39085, Potterwalkalgee Creek, 34°08'S 141°23'E; D56882–83, Potterwalkalgee Creek, 5 km E. of Neds Station corner, 34°08'S 141°23'E; D61906, Dedman Creek, 13 km W. of Horseshoe Lagoon, Wallpolla Island, 34°08'S 141°42'E.

South Australia: MV D5297, Purnong, 34°51'S 139°38'E; D34282–83, Kingston [on Murray]; D34284–89, Torrens River Gorge, 34°52'S 138°46'E; D 39070–71, Cattambal, Torrens River Gorge. SAMA R2393A–B, Sturt River, Eden, 35°01'S 138°36'E; R2874, Mylor, 35°03'S 138°46'E; R2889, Bridgewater, 35°00'S 138°46'E; R11177, Torrens Gorge, 34°53'S 138°44'E; R13481, just N of Sinclair Flat, River Murray, 34°15'S 139°38'E; R13482, Waterfall Gully, 34°57'S 138°41'E; R18519, Glenforslan Ranch, 34°15'S 139°39'E; R22306–07, Sturt Creek, FlagstaffHill area, 35°02'S 138°32'E; R33009, Monoman Creek, Chowilla, 33°56'35"S 140°52'45"E; R33350, Clarendon, 35°07'S 138°38'E; R33782, Punkah Island, Chowilla Stn, 33°57'45"S 140°57'45"E; R37931, Scott's Lagoon, 8.5 km S of Morgan, 34°07'S 139°40'E; R38017, Lake Garnett, 20 km NE of Mannum, 34°53'S 139°31'E.

Other: MNHP 2977 'Nouvelle Hollande' (Syntype of *Lygosoma quoyii*). BMNH 1946.8.4.99, 'Kangaroo Island, S.A.' (in error); 1946.8.15.34–35, 'Queensland'; 1946.8.15.36, 'Australia'; (Types of *Hinulia gastrosticta*). NMW 16656:1–2, 'Kangaroo Island' (in error) (Types of *Hinulia gastrosticta*).

Eulamprus tympanum tympanum.

New South Wales: AMS R111949, Dora Dora National Park proposal area, 35°55'S 147°35'E (Holotype of *Eulamprus herseyi*).

Victoria: NHRM 3094, Neighbourhood of Melbourne (Holotype of *Lygosoma tympanum*). MV D11881–11883, Gellibrand River, 38°31'S 143°32'E; D12207–12216, Gellibrand, 38°31'S 143°32'E; D 13642–13645, Mt. Sabine 38°47'S 147°19'E; D13653–13654, Gellibrand River 38°31'S 143°32'E; D14056–14065, Dellys Dell 37°12'S 142°32'E; D15594, Near Halls Gap, 37°08'S 142°31'E; D17571, Gellibrand River 38°32'S 143°32'E; D33424, Junction of Mairs Track & Syphon Road, 37°11'S 142°20'E; D33491, 3 km S. of Ben Nevis, 37°15'S 143°12'E; D33492–33493, 4.8 km N. of Mt. Cole, 37°17'S 143°16'E; D33500, Grampian Ranges, 37°07'S 142°26'E; D33874, 14.5 km S. of Elmhurst, 37°18'S 143°15'E; D35846, Syphon Road, 37°10'S 142°20'E; D35847, Moora Hut, 34°14'S 142°26'E; D35848–35849, 3.2 km W. of Pirron Yallock, 38°21'S 143°23'E; D3579, Back River Bridge, 8 km W. of Bentleys Plains, 37°14'S 147°49'E; D35794, 12.9 km E. of Moutys Hut; D35795, Ridge over Nuniong Plains, 37°08'S 147°57'E; D35798–800, 3.2 km W. of Cape Horn, 38°44'S 143°34'E; D35802, Great Ocean Road, 3.2 km W. of Apollo Bay, 38°46'S 143°37'E; D 35806, D35808–09, Dargo High Plains, 37°06'S 147°09'E; D35830–33, D35835–39, Lake Mountain road, 6.8 km. from Cumberland road, 37°31'S 145°52'E; D35852–35854, Matlock road, 54.7 km N. of Noojee, 37°24'S 146°0'E; D35855–35856, Matlock road, 37 km N. of Noojee, 37°34'S 146°0'E; D35857, Big River Camp, 37°32'S 145°57'E; D35858–35859, 51.5 km N. of Noojee, 37° 26'S 146° 0'E; D35860–35861, 24 km N. of Noojee, on Matlock Road, 37°41'S 146°0'E; D35862, 66 km N. of Noojee on Frenchmans Spur road, = 29 km E. of Big R. camp,37°32'S 145°57'E; D35863, Wartook, 37°02'S 142°21'E; D35864, 13.7 km N.W. of Peterborough, 38°30'S 142°45'E; D35865, Lake Wartook, 37°05'S 142°27'E; D35866, 4.8 km N. of Tyers, 38°06'S 146°28'E; D35867, 4 km N. of Streiglitz, 37°50'S 144°11'E; D35868, Badger Ck., Healesville, 37°34'S 145°35'E; D35869, Memorial Gardens, Mt. Macedon, 37°22'S 144°35'E; D35870–35871, 8.8 km E. of Marysville, 37°31'S 145° 50'E; D35872, 21 km S.E. of Cumberland Junction 37°42'S 146°04'E; D35881, Fyans Creek, 61 km. N. of Dunkeld, 37°05'S 142°34'E; D35891, Wartook Reservoir, 37°05'S 142°27'E; D35985, Chimney Pot Gap, 37°24'S 142°18'E; D 35985, D35987–90, Chimney Pot Gap, 37°24'S 142°18'E; D35993, Lake Wartook, 37°05'S 142°27'E; D36001, Blanket Bay, 38°49'S 143°35'E; D36002, 8 km N. of Cape Horn, 38°39'S 143°37'E; D36018–36028, 8 km N. of Cape Horn, 38°39'S 143°37'E; D36063–36067, 3.2 km W. of Cape Horn, 38°44'S 143°34'E; D36092–36093, Enfield, 12.8 km S. of Ballarat, 37°45'S 143°47'E; D36173, Lake Wartook, 37°05'S 142°27'E; D36307–36309, Mt. Sabine, 38°38'S 143°44'E; D39399, Mt. William, 37°13'S 144°48'E; D39401–39406, 4 km S. of Ben Nevis fire tower, 37°16'S 143°12'E; D39407, Lake Wartook, Grampian Road 37°05'S 142°27'E; D47759, 4 km W.S.W. of Enfield, 37°45'S 143°45'E; D47760, 3 km W. of Enfield, 37°45'S 143°45'E; D47804–47807, Glenisla Shelter, Victoria Range, 37°09'S 142°15'E; D47808, Mt. William, 37°13'S 144°48'E; D47915, 0.5 km N. of Mt. Langi Ghiran, 37°17'S 143°08'E; D48690, Nowhere Creek, 37°07'S 143°17'E; D48691, Mt. Avoca, 37°06'S 143°21'E; D48709–11, 5 km N.E. of Glenlofty, 37°05'S 143°15'E; D50183–50185, 1 km S. of Mt. Lonarch, 37°16'S 143°21'E; D50257–58, 4 km W. of Mt. Buangor, 37°18'S 143°11'E; D50716–19, Mt. Avoca, 37°06'S 143°21'E; D50951–52, 1 km S.W. of Mt. Sabine, 38°38'S 143°43'E; D50966, Mt. Sabine 38°37'S 143°44'E; D56657, Hopkins Falls, 38°20'S 142°37'E.

South Australia: SAMA R11263, Sect. 123, Hund. of Young, County Grey, 37°43'S 140°45'E; R12400, Southernmost point, Sect. 123, Hund. of Young, County Grey, 37°43'S 140°46'E; R12982, NW of Port Macdonnell, 37°59'S 140°33'E; R13076, SW of Mount Gambier, 37°54'S 140°41'E; R14123, N of Mount Gambier, 37°44'S 140°50'E; R14868, SE of Mount Gambier, 37°55'S 140°57'E; R15163A–B, Sect. 391, Hund. of Caroline, 37°58'S 140°51'E; R16826A–C, Rivoli Bay, 37°32'S 140°06'E; R17889, 5 km N of Wandilo siding, 37°41'S 140°44'E; R19082–83, N of Mount Gambier, 37°42'S 140°46'E; R23890, R23952, Woolwash Creek near Port Macdonnell, 38°03'S 140°45'E; R23926, 10 km NW of Port Macdonnell, 38°00'23"S 140°36'11"E.

E. t. tympanum x marnieae intergrade specimens.

Victoria: D39412, 16 km N. of Camperdown, 38°01'S, 143°09'E; D52910–11, 1.5 km N. of Kariah, 38°10'S, 143°13'E; D56721, 11.5 km NNE of Camperdown, 38°08'S, 143°12'E; D56802, 4.5 km E (100°) of Bookar, Lake Colongulac, 38°10'S, 143°10'E; D56803, 4.6 km ESE (105°) of Cororooke, 38°10'S, 143°32'E; D56804, D56878, 3.4 km SE (130°) E of Cororooke, 38°17'S, 143°33'E.

Eulamprus tympanum marnieae

Victoria: HOLOTYPE: NMV D52921, 5.5 km E. of Dreeite, Victoria, 38°11'S, 143°34'E, P. A. Rawlinson & M. Hutchinson, 1 November, 1979.

PARATYPES: 5.5 km E. of Dreeite: D49377, D49391–92, P. A. Rawlinson & M. Hutchinson, 1 September 1977; D52912–20, D52922–529266, P.A. Rawlinson & M. Hutchinson, 30 October and 1 November, 1979; D62035, M. Hutchinson & S. Donnellan, September, 1986. 5 km E of Dreeite, 38°11'S, 143°34'E, D52955–56, G. Brown, 9 November 1979; D53977–80, G. Brown, 25 January, 1980. Dreeite, Taits Road, 38°11'S, 143°31'E: D49385–87, M. Hutchinson & G. Ingram, 26 August 1977; D49388–90, P. A. Rawlinson & M. Hutchinson, 1 September 1977.

REFERRED SPECIMENS: D36075–84, 8 km S. of Lismore, 38°01'S, 143°20'E, S. Hosgood, 16 April, 1963; D52600–01, Lake Bolac, near caravan park, 37°44'S, 142°52'E, M. Hutchinson & G. Brown, 23 February 1978; D52901–09, Lake Bolac, near caravan park, 37°44'S, 142°52'E, P. A. Rawlinson & M. Hutchinson, 31 October 1979.

RECORDS OF THE SOUTH AUSTRALIAN MUSEUM

VOLUME 29
1996–7

Published by the South Australian Museum,
North Terrace, Adelaide, South Australia 5000.

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Volume 29(1) was published on 29 July 1996.
Volume 29(2) was published on 8 April 1997.

ISSN 0376–2750

NEW RECORDS AND DESCRIPTONS OF TRYPANORHYNCH CESTODES FROM AUSTRALIAN FISHES

I. BEVERIDGE & R. A. CAMPBELL

BEVERIDGE, I. & CAMPBELL, R. A. 1996. New records and descriptions of trypanorhynch cestodes from Australian fishes. *Records of the South Australian Museum* **29**(1): 1–22.

Collections of trypanorhynch cestodes in the South Australian Museum, the Queensland Museum and the Australian Museum were examined. New host or geographical records as well as new morphological details are provided for the following species: Tentaculariidae: *Tentacularia coryphaenae* Bosc, 1797, *Nybelinia thyrsites* Korotaeva, 1971, *Nybelina sphyrnae* Yamaguti, 1952; Hepatoxylidae: *Hepatoxylon trichiuri* (Holten, 1802), *Hepatoxylon megacephalum* (Rudolphi, 1819); Sphyriocephalidae: *Sphyriocephalus tergestinus* Pinter, 1913; Otobothriidae: *Poecilancistrium caryophyllum* (Diesing, 1850); Lacistorhynchidae: *Callitetrarhynchus gracilis* (Rudolphi, 1819). *N. sphyrnae*, *H. megacephalum* and *S. tergestinus* are reported from Australia for the first time. The adult of *N. thyrsites* is described for the first time.

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Between 1985 and 1987, a survey of the cestode parasites in elasmobranch fishes in the Australian region was undertaken. The resulting collections, following the examination of 1 294 specimens belonging to some 98 species (Beveridge 1987, 1991) are now housed in the South Australian Museum. Prominent among the collections made were trypanorhynch cestodes including a number of new genera and species and other genera new to the Australian region (for summary, see Campbell & Beveridge 1994).

The purpose of this communication is to report additional species encountered during the survey, several reported for the first time from Australia, or from collections already housed in the South Australian Museum, the Australian Museum and the Queensland Museum. A substantial collection of larval trypanorhynchs from teleost fishes has also been made available for study by various colleagues, and the collation of data on the occurrence of both adult and larval forms provides ecological insight into the life-cycles of the parasites concerned. In addition, new observations are included on the morphology of several of the cosmopolitan species encountered.

Illustrations are provided for the species discussed. Particularly with trypanorhynch cestodes, adequate illustrations provide clear evidence of the accuracy of identifications made, without reliance on textual description. Written descriptions are provided only for species that have been poorly described or which have not been described as adults in the past.

Materials And Methods

Adult cestodes collected by the writers were washed in sea-water or tap-water and fixed in hot 70% ethanol or hot 10% formalin. In some instances, spiral valves were opened, cestodes were killed *in situ* by flooding the gut with near boiling water and formalin was added immediately to fix the cestodes. In the laboratory, cestodes were removed from spiral valves, cleaned in water and were stored in 70% ethanol. Plerocerci were dissected free of any enclosing membranes and placed in tap-water to induce eversion of tentacles, then fixed in 70% ethanol. Cestodes were examined either as temporary mounts in glycerol or were stained in Celestine blue, dehydrated in ethanol, cleared in clove oil and mounted permanently in Canada balsam. Tentacles were removed from some specimens and mounted in glycerine jelly. The taxonomic arrangement and terminology for anatomical features and for hook patterns follows Campbell and Beveridge (1994). Synonymies of well established species are not provided, as they are available in considerable detail in Dollfus (1942).

Synonymies are provided for species which are not treated in Dollfus (1942) or which are not obtainable from other readily available sources. Measurements are presented in millimetres as the range followed by the mean in parentheses. Unless otherwise stated, mean values are based upon ten individual measurements. Where fewer than ten measurements were available, the number made is indicated by n.

The following abbreviations are used for institutions:

AHC Australian Helminthological Collection, South Australian Museum, Adelaide

AM Australian Museum, Sydney

BMNH British Museum (National History), London (now The Natural History Museum)

MNHN Muséum national d' Historie naturelle, Paris

MPM Meguro Parasitological Museum, Tokyo, Japan

QM Queensland Museum, Brisbane

TINRO Tikhookeanskogo Nauchno – issledovatelskogo Institut Rybnogo Khozyaistva i Okeanaografii (Pacific Scientific Research Institute. Fisheries, Economics and Oceanography), Vladivostock, Russia.

The personal collection from which cestodes were borrowed was that of Dr. R .J. G. Lester (RJGL). Host nomenclature follows Last and Stevens (1994) for elasmobranchs and Gomon *et al.* (1994) and Paulin (1993) for teleosts in southern Australian waters.

Systematics

Order TRYPANORHYNCHA Diesing, 1863

Superfamily HOMEACANTHOIDEA Dollfus, 1942

Family TENTACULARIIDAE Poche, 1926

Genus *Tentacularia* Bosc, 1797

Tentacularia coryphaenae Bosc, 1797
(Figs 1–6, 54–55)

Synonymy — see Dollfus (1942)

Material examined

Adults. From *Carcharhinus melanopterus* (Quoy & Gaimard, 1824): 3 scoleces, strobilar fragments, 'Port-Western, Australie', collected 1829, (MNHN A_2R – 1142); 3 specimens, Bundaberg, Qld. (QM GL 10806–10821). From *Carcharhinus limbatus* (Valenciennes, 1839): 1 specimen, Darwin, N.T. (AHC 24935).

Metacestodes. From *Xiphias gladius* Linnaeus, 1758: 4 specimens, Cronulla, N.S.W. (AHC S711, S2528). From *Coryphaenae hippurus* Linnaeus, 1758: 8 specimens, Barwon Banks, 20 miles NE of Mooloolaba, Qld. (AHC 18497–8). From *Macruronus novaezelandiae* (Hector, 1871): 2 specimens, west coast of Tasmania (QM G212139).

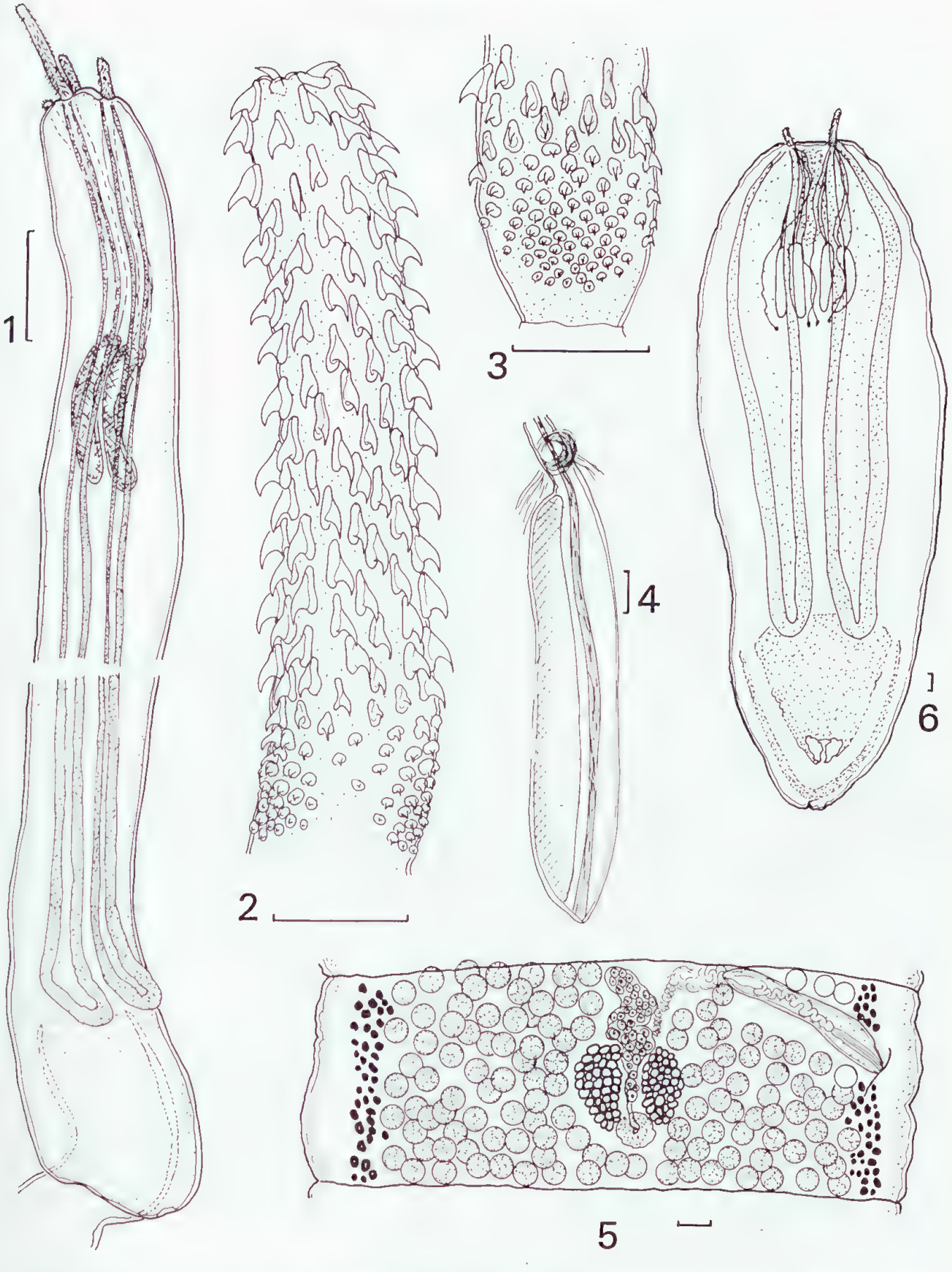
Remarks

This cosmopolitan species has been recorded only three times from Australian waters. The first record by Dollfus (1930, 1942), omitted in the checklist of Beumer *et al.* (1982), was based on specimens collected by Quoy and Gaimard in 1829 during the visit of the 'Astrolabe' to Australia under the command of Dumont D'Urville. The collection details associated with the specimen indicate that it was collected at 'Port-Western'. The 'Astrolabe' visited Westernport, Victoria, but *Carcharhinus melanopterus* is a tropical shark and does not occur in Victorian waters (Last & Stevens 1994). 'Port-Western', the locality associated with the labels, is unquestionably Westernport, Victoria as it occurs under this name in earlier maps such as Freycinet's General Chart of New Holland published in 1811 (Horner 1987 : 21). Hence, it is possible that the recorded locality is incorrect. As the voyage continued through the south-eastern Pacific, it is also possible that Quoy and Gaimard's specimens were in fact not from Australian waters, or that the host was not correctly identified.

T. coryphaenae has also been reported in *Katsuwonus pelamis* (Linnaeus, 1775) from New South Wales and Norfolk Island by Lester *et al.* (1985) and Korotaeva (1971) reported it from *Ruvettus pretiosus* Coco, 1829 (syn. *R. tidemani* Weber, 1913) from the Great Australian Bight.

The new collections confirm *C. melanopterus* as a host for the parasite in Australian waters and add the intermediate hosts *Xiphias gladius, Coryphaenae hippurus* and *Macruronus novaezelandiae,* all of which are new records for Australian waters.

A detailed summary of the anatomy of *T.*



FIGURES 1–6. *Tentacularia coryphaenae* Bosc, 1797. **1.** Scolex. **2.** Tentacle, internal surface. **3.** Basal armature of tentacle, bothridial surface. **4.** Tentacular bulb. **5.** Mature proglottis. **6.** Post larva. Figures 1–5 based on material from *Carcharhinus melanopterus* Quoy & Gaimard, 1824 (in MNHN A_2R–1142). Scale bars: Figure 1, 1.0 mm; Figures 2–6, 0.1 mm.

coryphaenae was provided by Dollfus (1942), however, several significant features of the tentacular armature, illustrated in Figs 2 and 3, warrant comment. Some members of the Homeacanthoidea were considered by Campbell and Beveridge (1994) to display bilateral symmetry in the metabasal tentacular armature, in contrast to previous authors (e.g. Dollfus 1942) who considered the symmetry to be entirely rotational. The basal armature of *T. coryphaenae*, was illustrated by Dollfus (1942), Subhapradha (1955) and Campbell and Beveridge (1994), but none of these authors have commented on the fact that *T. coryphaenae* provide an example of rotational symmetry in the metabasal armature and bilateral symmetry in the basal armature. The internal and external surfaces of the tentacle are identical, unlike the situation in the heteroacanthous trypanorhynchs (Campbell & Beveridge 1994), in which the rows form a pattern of V-s on the internal surface and Λ-s on the external surface. The hooks on the base of the tentacle are arranged in ascending rows similar to the pattern found in heteroacanths, while in the metabasal region, the hooks are arranged in a quincunxial pattern, typical of homeoacanths.

Genus *Nybelinia* Poche, 1926

Some 42 species have been described in the genus *Nybelinia*, many very poorly, rendering its taxonomy difficult. Dollfus (1942) described or redescribed 14 species, regarding an additional three as *inquirendae*, and subsequently (1960) added 16 new species, mainly from fish from West Africa. Four new species were described by Yamaguti (1952) from Japanese fish, three more species from fish from the Indian Ocean were added by Reimer (1980) and single species were described by Heinz and Dailey (1974) from California, by Carvajal *et al.* (1976) from Hawaii, and by Shah and Bilqees (1979), Kurshid and Bilqees (1988) and Chandra (1988) from India and Pakistan.

Separation of species is based primarily on hook size, shape and uniformity, and secondarily on the proportions of the different regions of the scolex. The genus has been divided into two subgenera, *Nybelinia* and *Syngenes*, by Dollfus (1942), based on whether the proglottides are acraspedote or craspedote. However, as the adult is not known for most of the described species, few can be assigned to subgenus. Subgenera were not considered by Campbell and Beveridge (1994) for this reason.

Beumer *et al.* (1982) listed only one species, *N. thyrsites*, from the Australian region. Korotaeva (1971) named this species, previously known simply as '*Nybelinia sp.*' from larval stages only. The adult is described here for the first time.

Nybelinia thyrsites Korotaeva, 1971
(Figs 7–14)

Nybelinia thyrsites Korotaeva, 1971: 74–6, fig. 4.

Nybelinia thyrsites (Leiper & Atkinson, 1915) *in* Beumer *et al.*, 1982: 18.

Tetrarhynchus sp. of Leiper & Atkinson, 1915: 56–6, fig. 35.

Nybelinia (*Syngenes*) sp. of Dollfus, 1942: 195–7, figs 109–110.

Nybelinia (*?Syngenes*) sp. of Robinson, 1959: 146, figs 1–3.

Types

Metacestodes from abdominal cavity of *Thyrsites atun* (Euphrasen, 1791), Southern Australia in TINRO ANZ 4–35 (not examined).

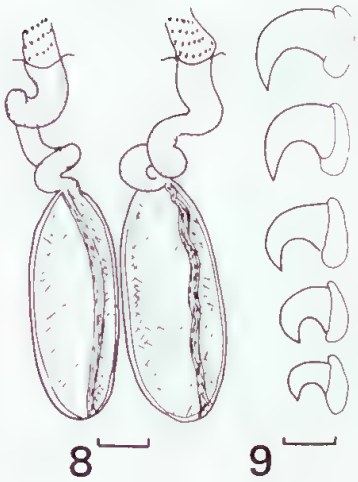
Material examined

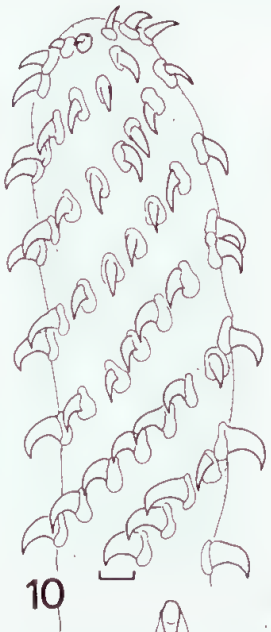
Adults. From *Mustelus antarcticus* Guenther, 1870: 19 specimens, Goolwa, S.A. (AHC S17515–20). From *Carcharhinus brachyurus* (Guenther, 1870): 4 specimens, Goolwa, S.A. (AHC 17514). From *Galeorhinus galeus* (Linnaeus, 1758): 1 specimen, Pt Willunga, S.A. (AHC 312). From *Aptychotrema vincentiana* (Haake, 1885): 2 specimens, Goolwa, S.A. (AHC 17521).

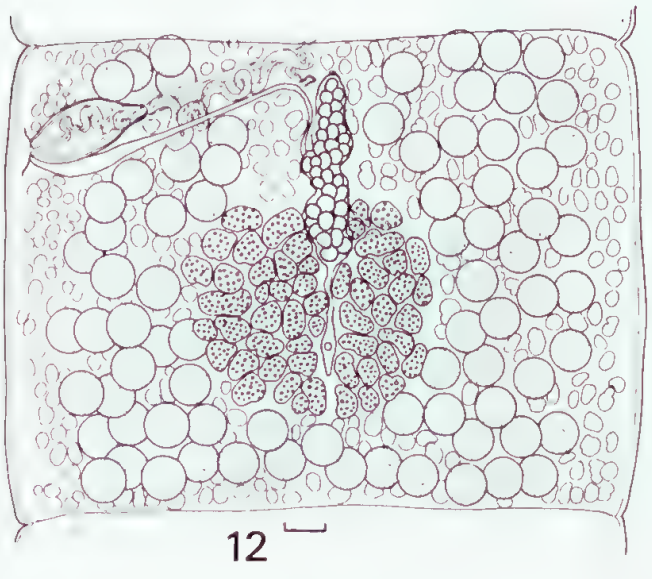
Metacestodes. From *Arripis truttaceus* (Cuvier, 1829) (syn. *A. esper* Whitley, 1950): 2 specimens, Goolwa, S.A. (AHC 17522). From *Lepidopus caudatus* (Euphrasen, 1788): 1 specimen, Bay of Islands, New Zealand (BMNH 1914. 6.1 493–496B); 3 specimens, North Cape, New Zealand (BMNH 1914. 6.1 535–554). From unknown host: 2 specimens, locality unknown, coll. in 1829 by Quoy and Gaimard (MNHN A_2R. 1140)

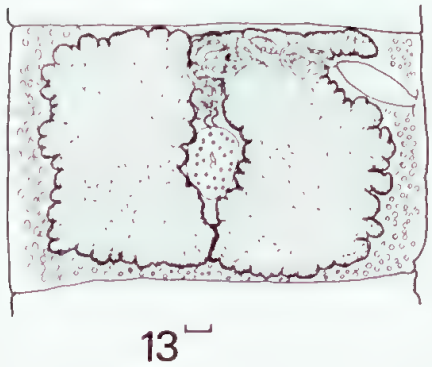
Description

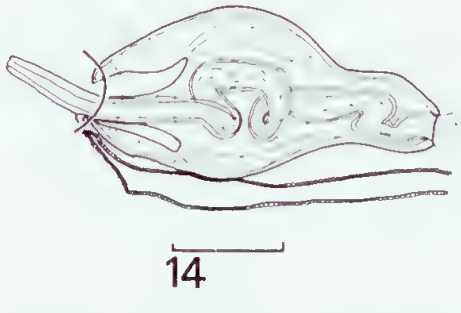
Cestodes of moderate size, up to 173 long, 1.9 maximum width, with up to 312 proglottides in gravid specimens. Scolex craspedote, subspherical anteriorly, truncated posteriorly;











FIGURES 7–14. *Nybelinia thyrsites* Korotaeva, 1971. **7.** Scolex. **8.** Bulbs and sheaths. **9.** Profiles of hooks along tentacle showing gradual increase in hook size. **10.** Distal region of tentacle, bothridial view. **11.** Basal region of tentacle, bothridial view. **12.** Mature proglottis. **13.** Gravid proglottis. **14.** Cirrus sac and vagina. Specimens from *Mustelus antarcticus* Guenther, 1870 (AHC S17515–20). Scale bars: Figures 7, 12–14, 0.1 mm; Figures 8–11, 0.01 mm.

maximum width 0.66–1.06 (0.83) in mid-region of bothridia; 4 bothridia, approximately reniform, external margin convex, internal margins concave; internal margin thicker than external, less variable in shape; area between dorsal and ventral pairs of bothridia distinctly cordiform. Surface of bothridium covered with elongate microtriches; pars bothridialis 0.43–0.72 (0.61); pars vaginalis 0.13–0.52 (0.32), always shorter than pars bothridialis; sheaths irregularly coiled; bulb ellipsoidal, approximately three times longer than wide, 0.31–0.40 (0.37) long by 0.10–0.16 (0.13) wide. Retractor muscle of tentacle originates at base of bulb. Pars post-bulbosa 0.010–0.024 (0.017; n=4); bulbs end either adjacent to pars proliferans of strobila or separated from it by space; velum 0.30–0.80 (0.55) long, posterior border sometimes straight, sometimes irregular in shape.

Tentacles 0.44–0.58 (0.52) long, tapering distally; width at base (without hooks) 0.040–0.096 (0.054), width at mid-region 0.028–0.064 (0.045); width occasionally variable with narrower section in middle, which may be processing artefact. Hooks arranged in 24–27 (26; n=8) oblique rows, with 7–8 (7.8) hooks per half-turn; hooks uncinate, relatively uniform in shape, with point gently curved posteriorly; hook length 0.016–0.020 (0.019), base 0.009–0.012 (0.010); hooks at base of tentacle slightly smaller, but of same shape.

Strobila acraspedote, apolytic; mature proglottides slightly wider than long 0.41–1.12 (0.76) by 0.77–1.70 (1.25). Genital pore submarginal, opening on ventral surface, in anterior third of proglottis 0.13–0.32 (0.23) from anterior margin, alternate irregularly. Cirrus sac small, ellipsodial to subspherical, muscular wall weak, 0.18–0.35 (0.28) by 0.06–0.16 (0.12); cirrus unarmed; internal and external seminal vesicles absent; vas deferens coils anteriorly towards midline; vasa efferentia not seen. Testes 84–111 (98) in number, variable in size, 0.048–0.104 (0.071) in diameter; smallest testes near periphery of proglottis, distributed in single layer, confluent posterior to female genitalia; frequently not confluent anterior to female genitalia; rarely overlying female genitalia. Vagina narrow, straight tube, sometimes slightly dilated at distal end; vagina passes antero-medially, then turns posteriorly to descend towards ovary, terminating in diminutive seminal receptacle approximately 0.16 by 0.06. Ovary just posterior to centre of proglottis, bilobed in whole mounts, 0.30–0.60 (0.45) by 0.40–0.80 (0.56). Mehlis' gland small, spherical, situated posterior to centre of ovary, approximately 0.24 in diameter. Vitelline follicles encircling medulla, 0.016–0.048 (0.032) in diameter. Uterine duct ascends to join uterus anterior to ovary. Uterus sacciform, in shape of inverted U anterior to ovary; arms of gravid uterus elongate, filling with eggs until dilated arms meet posteriorly; posterior part of uterine arms become filled with eggs while anterior part contains relatively few eggs, finally occupying entire medulla. Uterine pore absent. Eggs spherical, 0.024–0.040 (0.032) in diameter; unembryonated.

Remarks

The first description of this species was given by Leiper and Atkinson (1915) based on metacestodes collected from *Lepidopus caudatus* (Euphrasen, 1788) from the Bay of Islands, New Zealand, during the British Antarctic Expedition of 1912–1913. Deposited with material in the British Museum (National History) is a series of specimens from the same host species, collected at North Cape, New Zealand (BMNH 1914, 6.1, 535–54) on the same expedition but not mentioned in their publication. They named their material simply '*Tetrarhynchus* sp.' Dollfus (1942) described in some detail metacestodes from an unknown teleost collected by Quoy and Gaimard in 1829 during the voyage of the 'Astrolabe' to Australia and the Pacific region. These specimens (MNHN $A_2R.$ 1140) he identified as *Nybelinia* (? *Syngenes*) sp. and considered them to be identical with Leiper and Atkinson's (1915) specimens. Robinson (1959) subsequently described the same species from metacestodes collected from *Thyrsites atun* (Euphrasen, 1791), *Zeus faber* Linnaeus, 1758 and *Trachurus novaezealandiae* Richardson, 1843 from Cook Strait, New Zealand, employing the same nomenclature as Dollfus (1942). He noted that every specimen of *Thyrsites atun* examined was heavily infected, while specimens of *Lepidopus caudatus* were not infected. He suggested that Leiper and Atkinson (1915) had misidentified the host species.

Korotaeva (1971) proposed the name *N. thyrsites* for apparently the same metacestode collected from Australian waters from the abdominal cavity of *Thyrsites atun*. The types are held in TINRO and were not examined. However, the material described by Leiper and Atkinson (1915) as well as that described by Dollfus (1942) was examined and compared with a metacestode and numerous adult specimens from

South Australian waters. All were judged to be conspecific and the adult is described here for the first time. Dollfus (1942) speculated on the basis of hook morphology, that the species belonged to the sub-genus *Syngenes* which is characterised by craspedote proglottides. In fact, the proglottides of the adult are acraspedote and the species therefore belongs to the sub-genus *Nybelinia*.

The adult of this species was found commonly in the gravid state in the stomach of *Mustelus antarcticus*. In other definitive hosts, the specimens were small and immature. Two immature speciments of *N. thyrsites* were found in only one of 35 *Aptychotrema vincentinana* examined.

Beumer *et al.* (1982) cited the species as *N. thyrsites* (Leiper & Atkinson, 1915) and were probably misled by Korotaeva's (1971) use of *nom. nov.* rather than *sp. nov.* at the head of her description. She stated however that the type specimen had been deposited in the collections held in TINRO (p. 75, 'typov'e exeplyap' khranyatsya v laboratorii parazitologii morskikh zhivotni'kh TINRO preparat' no. ANZ 4–35), clearly indicating that they are the types of a new species.

N. thyrsites is characterised by homoeomorphous hooks 18–20 µm long, of comparable size on both sides of the tentacle. Species with similar morphological features are *N. strongyla* Dollfus, 1960, *N. edwinlintoni* Dollfus, 1960, *N. eureia* Dollfus, 1960, *N. palliata* (Linton, 1924), *N. anantaramanorum* Reimer, 1980 and *N. lingualis* (Cuvier, 1817). *N. strongyla*, *N. anantaramanorum* and *N. lingualis* have sharply recurved hooks whose shape differs significantly from those of *N. thyrsites*. *N. palliata* belongs to the sub-genus *Syngenes* as the strobila is craspedote, whereas *N. thyrsites* has acraspedote proglottides and belongs to the sub-genus *Nybelinia*. *N. eureia* differs from *N. thyrsites* in having longer hooks (24–25 µm), a much longer pars postbulbosa of 0.54 mm compared with a maximum of 0.024 mm in *N. thyrsites*, in having a pars bothridialis which extends to the posterior end of the bulbs and in lacking an expansive bothridial fossa.

Nybelinia sphyrnae Yamaguti, 1952
(Figs. 15–17)

Nybelinia sphyrnae Yamaguti, 1952: 56–58, figs. 83–84.

Types

Adult cestodes from *pars pylorica* of *Sphyrna zygaena* (Linnaeus, 1758), Nagasaki, Japan, in MPM (not examined).

Material examined

Adults. From *Sphyrna zygaena* (Linnaeus, 1758): 3 specimens, Goolwa, S.A. (AHC 24958).

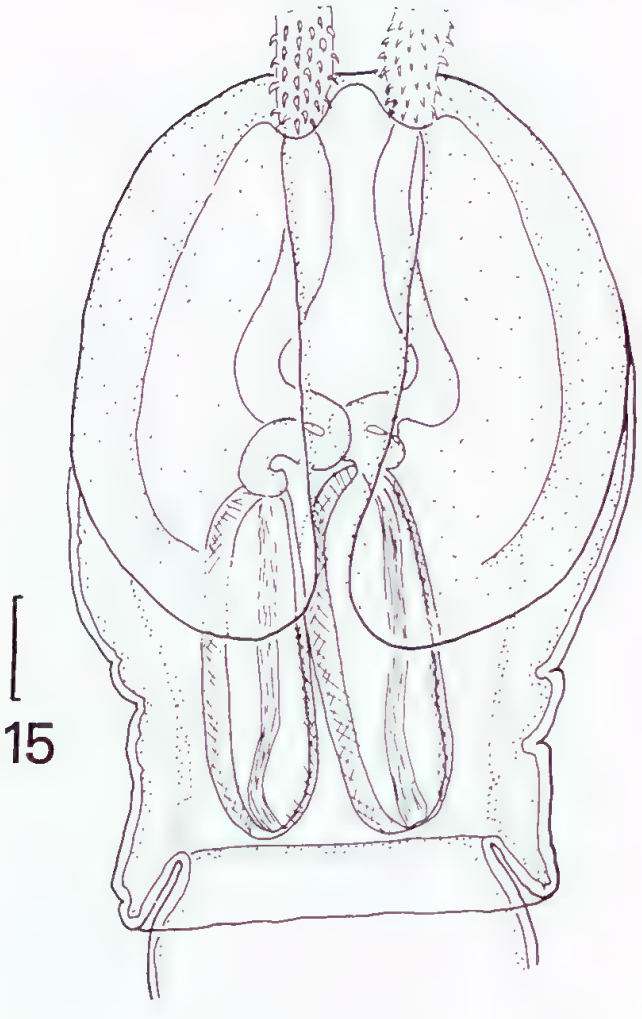
Remarks

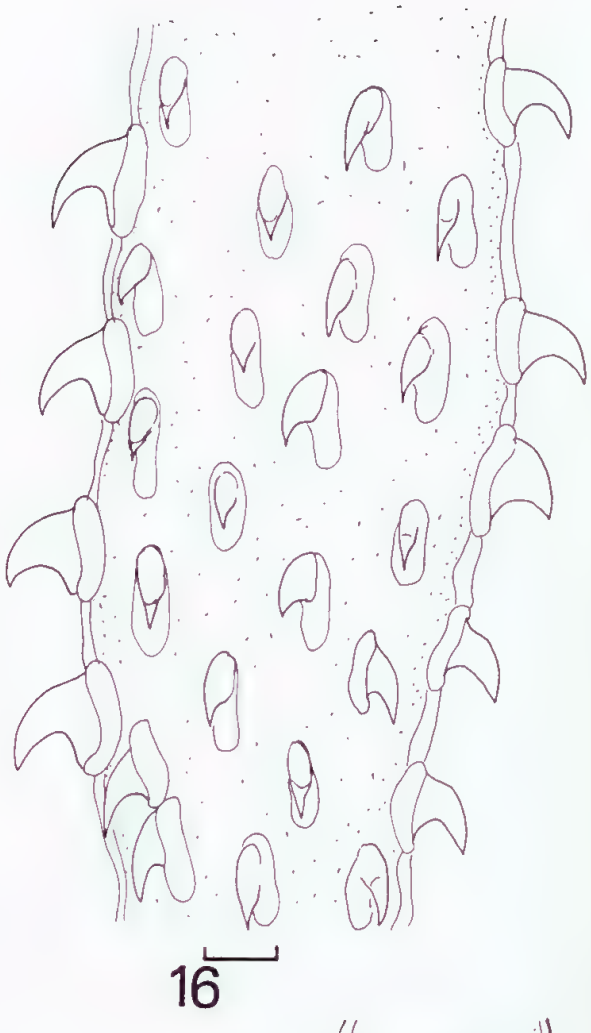
This species is readily recognisable from Yamaguti's (1952) description, and, as indicated by the illustrations, the Australian material is clearly referrable to this species. Yamaguti (1952) stated that an internal seminal vesicle was absent, however it is present in Australian specimens (Fig. 17), and Yamaguti's figure 84 shows a coiled proximal region of the cirrus which may form an internal seminal vesicle in fully mature proglottides. In addition, a small seminal receptacle was present in the Australian specimens, though not noted or illustrated by Yamaguti (1952).

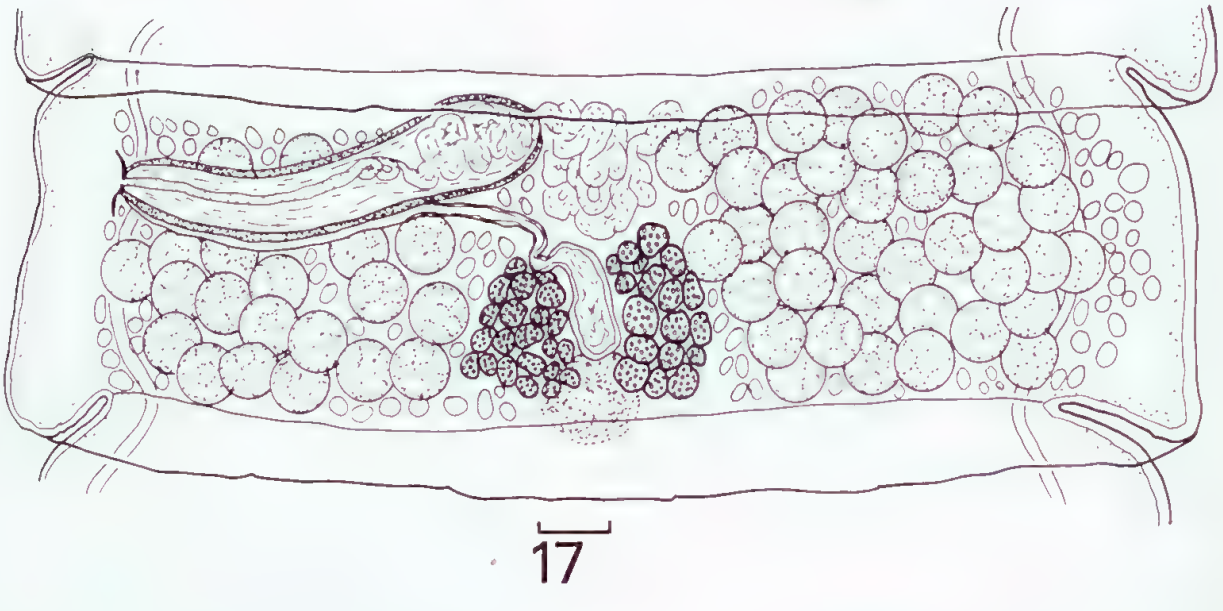
The species has not been reported subsequent to its original description (see Bates 1990), but would appear from the two records of the species to be restricted to *Sphyrna zygaena* in both northern and southern hemispheres.

N. sphyrnae differs from other species reported from hammer-head sharks, *N. edwinlintoni* Dollfus, 1960, *N. goreensis* Dollfus, 1960 from *Sphyrna lewini* (Griffith & Smith, 1834) (syn. *S. diplana* Springer, 1941) as well as *N. palliata* (Linton, 1924) and *N. syngenes* (Pinter, 1929) from *Sphyrna zygaena* in a number of features. Based on Pinter's (1929) description, it differs from *N. syngenes* in which the pars vaginalis exceeds the pars bothridialis and is differentiated from Linton's (1924) *N. palliata* in which the bothridia extend beyond the bulbs.

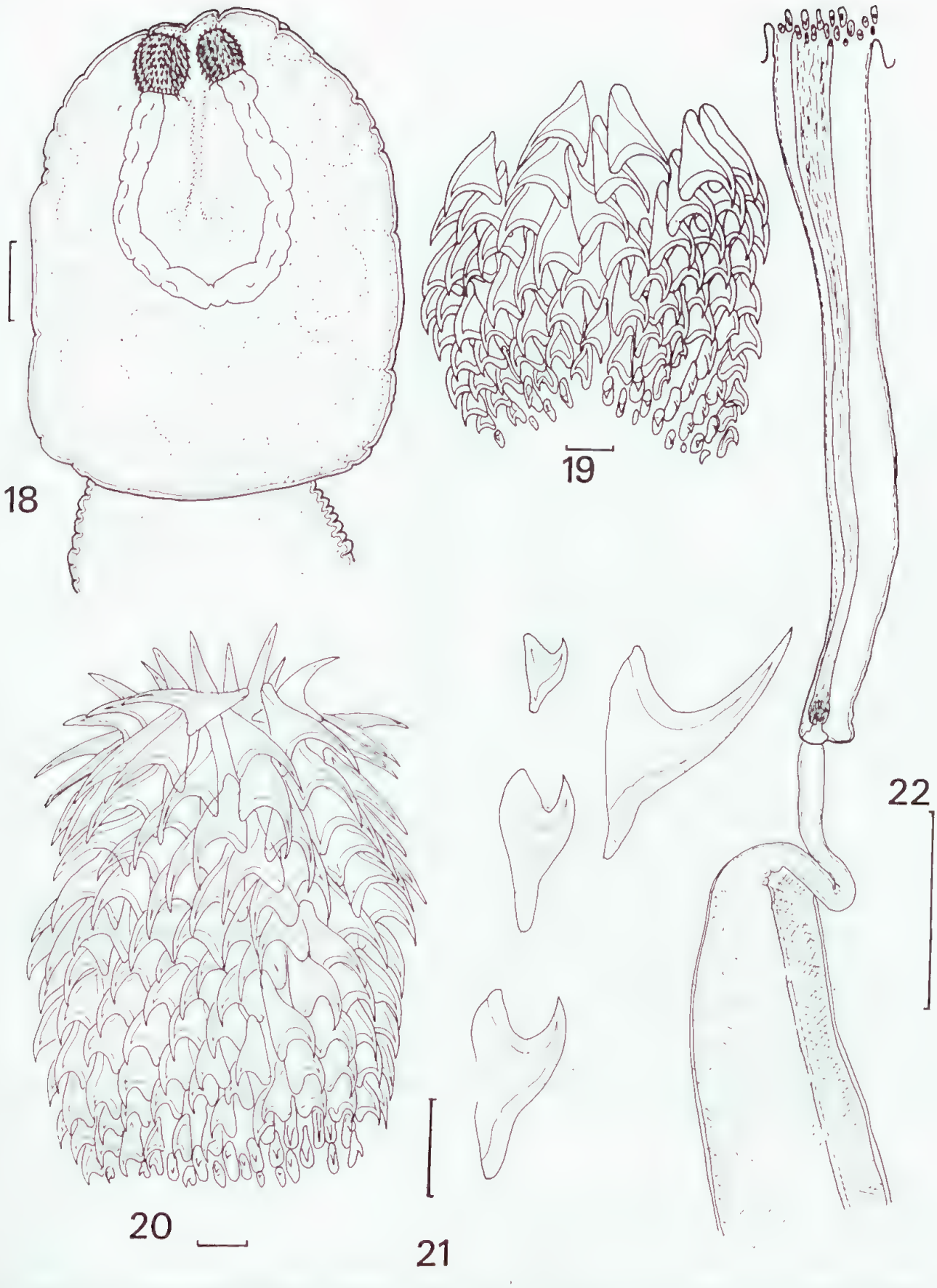
N. sphyrnae differs from *N. goreensis* as described by Dollfus (1960), in having smaller, more sharply recurved hooks (14–21 µm in *N. sphyrnae*, 27–30 um in *N. goreensis*) and a shorter velum (0.08–0.13 mm in *N. sphyrnae*, 0.18 –0.23 mm in *N. goreensis*). *N. sphyrnae* resembles *N. edwinlintoni* in hook size but differs in that *N. sphyrnae* has virtually no pars post-bulbosa, whereas in *N. edwinlintoni* it measures 0.29 mm. In spite of these apparent differences, the available descriptions of *N. palliata* are poor, while that of *N. edwinlintoni* is based on a single larval specimen. Therefore the identification is contingent upon *N. sphyrnae* being a valid species, recognizably distinct from those closely







FIGURES 15–17. *Nybelinia sphyrnae* Yamaguti, 1952. **15.** Scolex. **16.** Basal armature of scolex, bothridial view. **17.** Mature proglottis. Specimens from *Sphyrna zygaena* (Linnaeus, 1758) (AHC 24958). Scale bars: Figures 15, 17, 0.1 mm; Figure 16, 0.01 mm.



FIGURES 18–22. *Hepatoxylon trichiuri* (Holten, 1802). **18.** Scolex. **19.** Tentacle, basal region, internal surface, showing V-shaped area at base, free of hooks. **20.** Entire tentacle, bothridial surface. **21.** Series of alternate hooks of a single file in profile showing variation in size. **22.** Sheath and bulb showing origin of retractor muscle at junction of wide and narrow regions of sheath. Specimens from *Carchardon carcharias* (Linnaeus, 1758) (AHC 24933). Scale bars: Figures 18, 22, 1.0 mm; Figures 19–21, 0.1 mm.

related congeners on the basis of characteristics with which it is currently compared.

Family HEPATOXYLIDAE Dollfus, 1940

Genus *Hepatoxylon* Bosc, 1811

This genus contains two species which are cosmopolitan (Dollfus 1942), though Yamaguti (1959) and Schmidt (1986) considered them synonymous. Sin *et al* (1992) have recently provided electrophoretic as well as morphological evidence that the two species are valid.

Hepatoxylon trichiuri (Holten, 1802) (Figs 18–21, 56–57)

Synonymy — see Dollfus (1942)

Material examined

Adults. From *Carcharodon carcharias* (Linnaeus, 1758): 2 specimens, Dangerous Reef, S.A. (AHC 24933); 4 specimens, Seal Rocks, Phillip Is., Vic. (AHC 24934). From *Isurus oxyrinchus* Rafinesque, 1810: 2 specimens, Southern Australia (coll. RJGL).

Metacestodes. From *Xiphias gladius* Linnaeus, 1758: 1 specimen, Cronulla, N.S.W. (AHC 71, 1407, S2561, S2531, 17593); 6 specimens, Port River, S.A. (AHC 6668). From *Cyttus traversi* (Hutton, 1872): 1 specimen, west coast, Tasmania (Coll. RJGL). From *Coryphaena hippurus* Linnaeus, 1758: 1 specimen, Barwon Banks, 20 miles NE of Mooloolaba, Qld. (AHC 18499). From *Hoplostethus atlanticus* Collet, 1889: 1 specimen, west coast of New Zealand (QM G212141). From *Rexea solandri* Cuvier, 1831: 2 specimens, Great Australian Bight (QM G211886), 1 specimen, south-eastern Tasmania (QM G211887). From *Macruronus novaezelandiae* (Hector, 1871): 2 specimens, west coast of Tasmania (QM G212137).

Remarks

Records of this species from the Australian region are few, being those of Korotaeva (1974) from *Oplegnathus woodwardi* (Waite, 1900) (Syn. *Ostorhinchus conwaii* (Richardson, 1840)), Korotaeva (1971) from *Lepidopus caudatus* (Euphrasen, 1788) (syn *Lepidopus lex* Phillips, 1932) and Lester *et al.* (1988) from *Hoplostethus atlanticus* Collett, 1889 from southern Australia as well as a record from a lamprey, *Geotria australis* Gray, 1851 by Lethbridge *et al.* (1983). The present data therefore greatly extend the known host range of this species in Australian waters.

The species occurs in a range of teleosts and elasmobranchs in New Zealand waters (Robinson 1959; Waterman & Sin 1991), but the definitive host in the Australasian region has not been reported previously. The parasite is reported here for the first time from *Carcharodon carcharias* and *Isurus oxyrinchus*. The adult has been described by Lönnberg (1899), Joyeux and Baer (1934, 1936) and Yamaguti (1934), the details of which were summarised by Dollfus (1942). The histological anatomy of the plerocercus has been described in considerable detail by Rees (1941) under the name *Dibothriorhynchus grossum* (Rudolphi, 1819). The arrangement of hooks in the metabasal region is quincunxial (see Figs 56, 57) and on the bothridial surface, this pattern extends to the base (Fig. 57). On both the internal and external tentacle surfaces (Fig. 56), the ascending rows of hooks leave an inverted V-shaped area at the base of the tentacle, analogous to the arrangement seen in *T. coryphaenae*. This area is only clearly visible in tentacles dissected free from the scolex, and when this is done, it is extremely difficult to determine orientation of surfaces. Orientation in this case has been determined by analogy with *T. coryphaenae* and from one flattened, stained whole mount in which all the hooks are visible (AHC S2351). It has been assumed that flattening has not altered the arrangement of the hook rows.

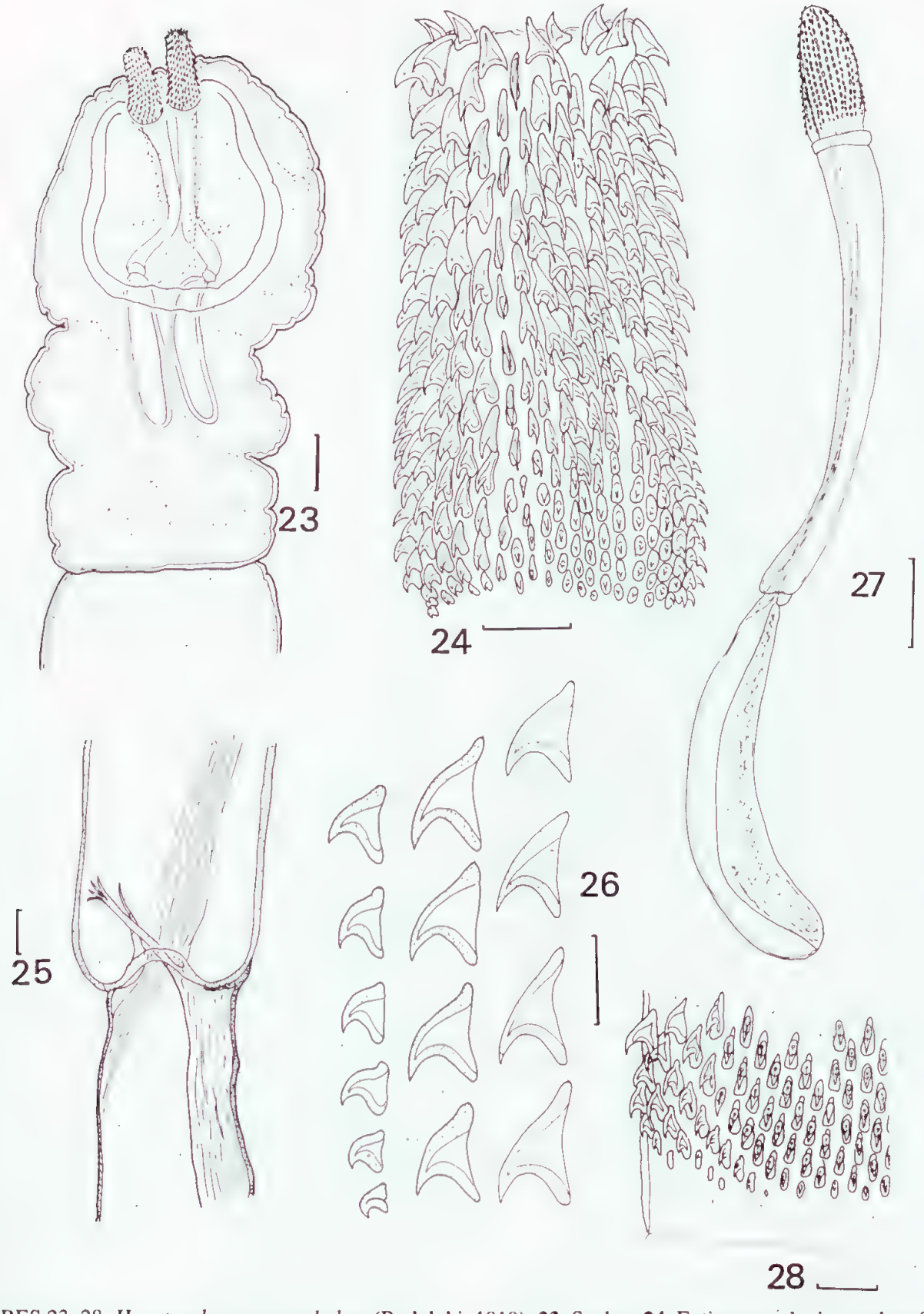
Hepatoxylon megacephalum (Rudolphi, 1819) (Figs 23–28, 58–59)

Synonymy — see Dollfus (1942)

Material examined

Adults. From *Carcharodon carcharias* (Linnaeus, 1758): 3 specimens, Kangaroo Island, S.A. (AHC 24932).

Metacestodes. From *Galeorhinus galeus* (Linnaeus, 1758): 1 specimen, Kangaroo Island, S.A. (AHC 17591); 1 specimen, Pt. Willunga, S.A. (AHC 593, S2564); 1 specimen, coast of N.S.W. (AM W 3452). From *Carcharhinus obscurus* (LeSueur, 1818) (Syn. *C. macrurus* (Ramsay & Ogilby, 1887): 2 specimens, Glenelg, S.A. (AHC 585, S2565). From *Squalus megalops* (Macleay, 1881): 2 specimens, south coast of N.S.W. (AM W 3359, W 3453). From *Squatina*



FIGURES 23–28. *Hepatoxylon megacephalum* (Rudolphi, 1819). **23.** Scolex. **24.** Entire tentacle, internal surface, showing V-shaped area at base, free of hooks. **25.** Junction of sheath and bulb, showing origin of retractor muscle. **26.** Series of single file of hooks in profile showing size variation. **27.** Rhyncheal system. **28.** Base of tentacle, bothridial view, internal surface to left, showing ascending rows of hooks around unarmed region at base. Specimens from *Carcharodon carcharias* (Linnaeus, 1758) (AHC 24932); Fig. 28 from *Galeorhinus galeus* (Linnaeus, 1758) (AHC 17591). Scale bars: Figures 23, 27, 1.0 mm; Figure 24, 0.2 mm; Figures 25, 26, 28, 0.1 mm.

australis Regan, 1906: 2 specimens, N.S.W. (AM W 3358)

Remarks

This species has not apparently been reported previously from Australia (see Beumer *et al* 1982) though it is well represented in museum collections. Plerocerci were found in several species of elasmobranchs, while the only adults seen were from *Carcharodon carcharias*.

The morphology of the plerocerus has been summarised by Dollfus (1942), with scanning electron microscopical observations by added Sin *et al* (1992), while the adult has been described from *C. carcharias* from New Zealand by Robinson (1959).

The rhyncheal system of this species has apparently not been described in detail. It appears to differ from that of *H. trichiuri* in that the sheaths are not divided into a distal region of greater diameter than the proximal section and in that the retractor muscle originates from the sheath close to the bulbs, rather than at the junctions of the two distinct regions of the sheath noted in *H. trichiuri* (see Rees, 1941).

As with *H. trichiuri, H. megacephalum* has an armature arranged in quincunxial fashion in the metabasal region, but with ascending hook rows leaving hook-free triangular areas at the base of the tentacle on the internal and external surfaces. The hook patterns in the metabasal region are not totally regular and if hook files are traced; several files from the base disappear in the metabasal region. The disappearance of files has been noted previously in the armature of *Sphyriocephalus dollfusi* by Bussieras and Aldrin (1968), though in that species, the arrangement of abbreviated files is symmetrical about the plane drawn through the mid-region of the external surface of the tentacle. In *H. megacephalum*, no symmetry in the reduction of hook files was noted.

Family SPHYRIOCEPHALIDAE Pintner, 1913

Genus *Sphyriocephalus* Pintner, 1913

Sphyriocephalus tergestinus Pintner, 1913 (Figs. 29 – 32, 60)

Synonymy — see Dollfus (1942)

Material examined

Metacestodes. From *Macruronus novaezelandiae* (Hector, 1871): 2 specimens, Tasmania (QM G212133–5).

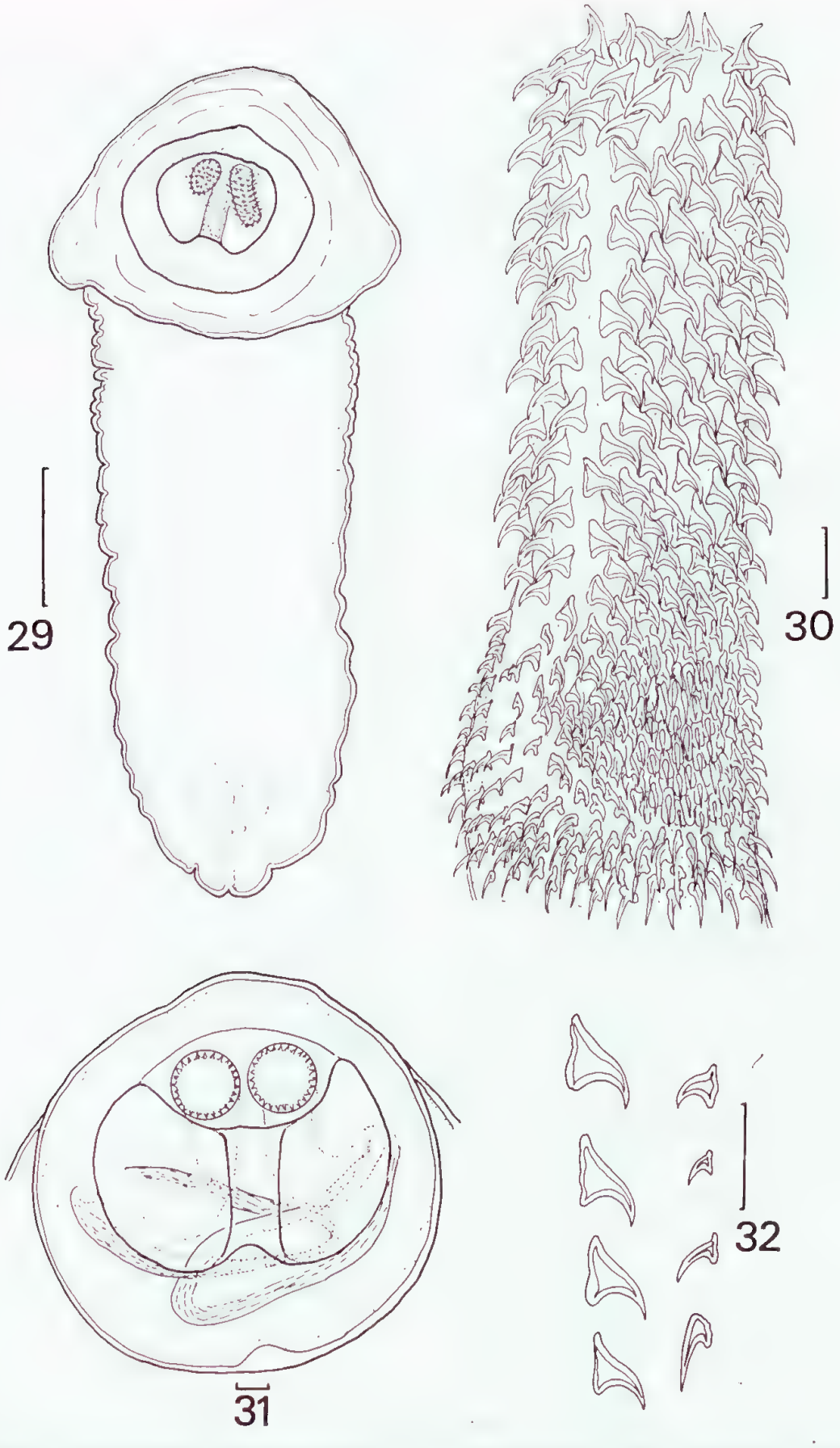
Remarks

The family Sphyriocephalidae has not previously been reported from Australian waters. The specimens illustrated here are tentatively referred to *S. tergestinus*, contingent upon subsequent clarification of the validity of species within the genus. Dollfus (1942) recognised two valid species, *S. viridis* and *S. tergestinus*, and listed (p. 116) a series of criteria by which the two could be distinguished. His synonymies assumed *S. alberti* to be a synonym of *S. viridis*, a situation subsequently confirmed by Bussieras (1970) who re-examined the types of *S. alberti*. The detailed descriptions of the armature of *S. alberti* given by Bussieras (1970) are the most detailed and informative descriptions of armature within the genus. Heinz and Dailey (1974) gave a very brief description of *S. pelorosoma* from *Alopias superciliosus* (Lowe, 1839) from California, based on a single specimen. The principal features they used for distinguishing their new species were the greater widths of the tentacles and relatively longer bulbs (Heinz & Dailey 1974). The latter character must remain questionable until measurements for *S. viridis* and *S. tergestinus* are available. Dollfus (1942) cited Pintner (1913) in reporting that the bulbs of *S. tergestinus* were twice as long as wide, yet illustrated them (Fig. 72) as being four times as long as wide. The value of this character in distinguishing species therefore remains uncertain until the extent of variation is established for *S. viridis* and *S. tergestinus*.

Bussieras and Aldrin (1968) described *S. dollfusi* based on plerocerci from tuna, *Thunnus obesus* (Lowe, 1839), distinguished from *S. tergestinus* and *S. viridis* in lacking a unique basal armature and having broad tentacles, similar in width to those of *S. pelorosoma*.

The specimens described here differ from *S. viridis* and *S. dollfusi* in that the sheaths are confined within the pars bothridialis. The specimens described conform with the description given by Dollfus (1942) of *S. tergestinus* and are therefore attributed to that species.

Bussieras (1970) noted that the armature of the metabasal region of the tentacle of *S. viridis* (= *alberti*) was arranged in an heteroacanthous pattern rather than an homeoacanthous pattern and questioned whether or not this was a specific characteristic. Although the current material of *S. tergestinus* is limited, it appears that it also has



FIGURES 29–32. *Sphyriocephalus tergestinus* Pintner, 1913. **29.** Plerocercus. **30.** Oblique view of tentacle with bothridial surface to lefthand side. **31.** Scolex of plerocercus, showing bulbs in transverse position, overlapped by the pars bothridialis. **32.** Tentacular hooks showing variation in shape between those of metabasal region (left file) and basal region (right file). Specimens from *Macruronus novaezelandiae* (Hector, 1871) (QM G212133–5).

glide reflection symmetry (Campbell & Beveridge 1994) in the arrangement of its armature in the metabasal region.

Superfamily OTOBOTHRIOIDEA Dollfus, 1942

Family OTOBOTHRIIDAE Dollfus, 1942

Genus ***Poecilancistrium*** Dollfus, 1929

Poecilancistrium caryophyllum (Diesing, 1850) (Figs 33 – 47)

Synonymy — see Dollfus (1942)

Material examined

Adults. From *Carcharhinus brachyurus* (Guenther, 1870): 8 specimens, Tathra, N.S.W. (AHC 24957);

Metacestodes. From *Pomatomus saltatrix* (Linnaeus, 1766): 3 specimens, Pt Jackson, N.S.W. (AHC 1410, S2563). From *Sillago robusta* Stead, 1908: 3 specimens, Qld. (QM G212164).

Description

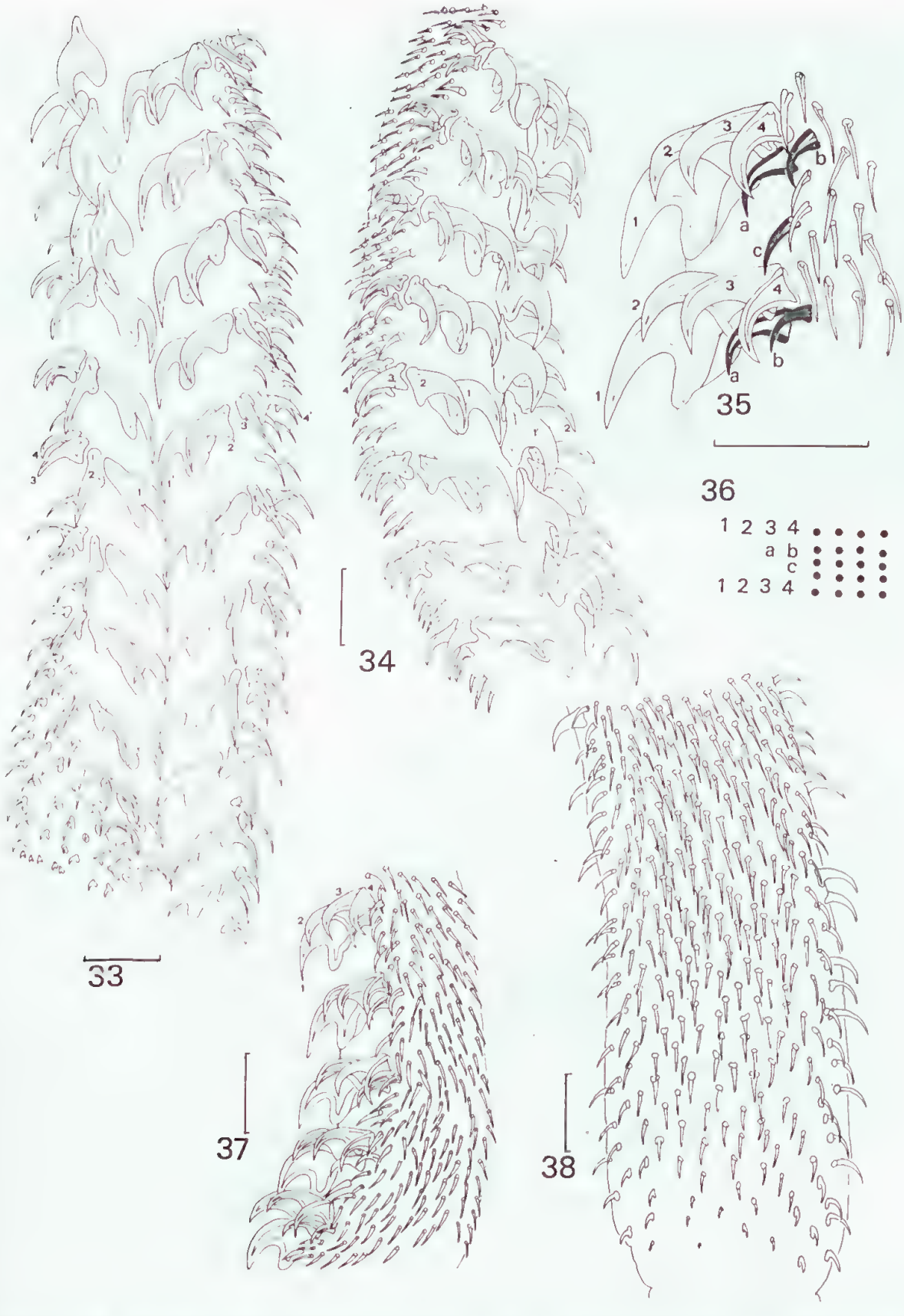
Cestodes of moderate size, up to 170 long, with up to 280 proglottides in gravid strobilae. Scolex 3.9–4.6 (3.3) (n=8) long, maximum width 1.1–1.4 (1.3) (n=8) in region of pars vaginalis; 2 bothridia, 2.0 (n=1) in diameter; almost circular, with indistinct, fleshy margins; pairs of sensory fossettes present in margin of each bothridium. Pars bothridialis 1.55–2.00 (1.77) (n=8). Pars vaginalis 1.65–2.48 (2.22) (n=8), sheaths not coiled, straight anteriorly, characteristically S-shaped posteriorly; pre-bulbar organ absent, but prominent muscle band encircling junction of sheath with bulb. Bulbs stout, 1.35–1.76 (1.59) (n=8) long by 0.32–0.42 (0.38) (n=8) wide; origin of retractor muscle at anterior end of bulb. Pars post-bulbosa approx. 0.22; velum absent. Tentacles stout, 0.08–0.13 (0.11) (n=7) in diameter in metabasal region, without basal swelling or distinctive basal armature. Armature heteroacanthous, atypical; principal hooks arranged in ascending rows; 4 hooks per row decreasing in size anteriorly; hooks 1(1') largest, 0.114–0.126 (0.120) long, strongly recurved, base prominent, 0.084–0.100 (0.087) long; hooks 2(2') smaller, 0.092–0.098 (0.095) long, base 0.048–0.052 (0.050); hooks 3(3') 0.068–0.082 (0.075) long, base 0.034–0.040 (0.036); hooks 4(4') smallest, 0.054–0.064 (0.061) long, base 0.022–0.032 (0.029).

Single intercalary row of hooks present between each major row; 2, sometimes 3, intercalary hooks per row, situated proximal to hooks 3(3') and 4(4') respectively; intercalary hooks a(a') 0.046–0.054 (0.049) long, hooks b(b') 0.036–0.046 (0.041) long; single hook, c(c') possibly representing second intercalary row, present posterior to other hooks. Internal surface of tentacle uniformly covered with numerous ascending rows of small hooks, 0.030–0.036 (0.034) long. Rows ascending with approximately 14 hooks per row; 4 rows per principal hook row.

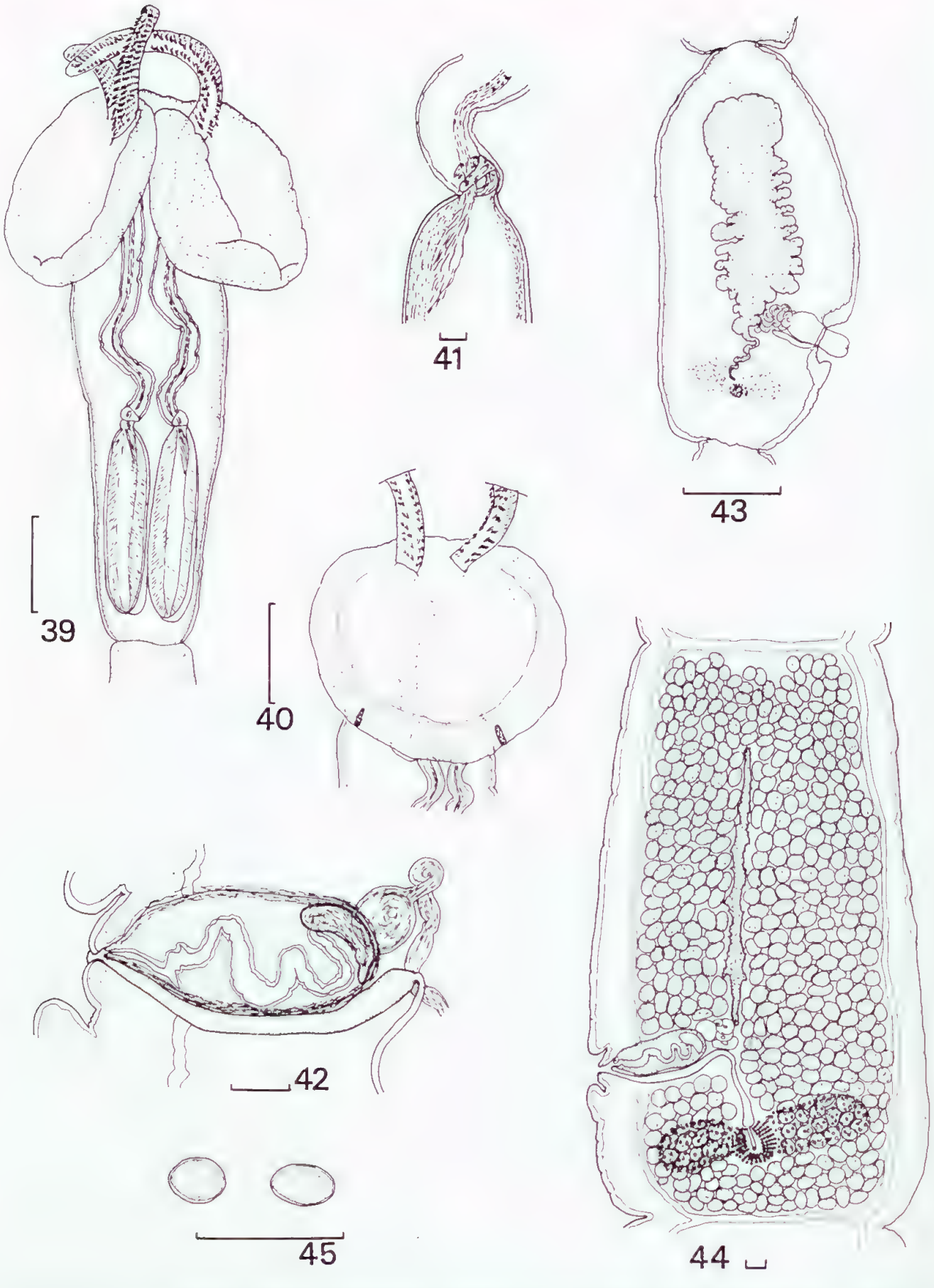
Mature proglottis 1.43–2.02 (1.78) (n=9) by 1.25–1.40 (1.30) (n=9); genital pore in posterior third of proglottis, 1.07–1.50 (1.28) (n=9) from anterior end of proglottis. Cirrus sac pyriform, thin-walled, 0.21–0.28 (0.25) by 0.14–0.19 (0.16); cirrus unarmed, slightly coiled, entering crescentic internal seminal vesicle; external seminal vesicle spherical, adnate to cirrus sac. Vas deferens coils posteriorly to region of ovary. Testes numerous, 550 (n=1) per proglottis, occupying entire medulla in single dorso–ventral layer; testis diameter 0.045–0.065 (0.053). Vagina opens to genital atrium posterior to cirrus sac; narrow, turning posteriorly at midline and descending towards ovary, dilating slightly at posterior end, but not forming distinct seminal receptacle. Ovary bilobed, each lobe 0.30–0.50 (0.45) by 0.20–0.28 (0.25); Mehlis' gland 0.15–0.19 (0.17) in diameter, posterior to ovarian isthmus. Uterine duct, without glandular investment, ascends to just anterior to cirrus sac; uterus with glandular wall extends anteriorly, not reaching anterior end of proglottis. Gravid proglottis 3.0 to 3.2 by 1.0 to 1.5; uterus initially linear, becoming sacciform with numerous small lateral branches; eggs ellipsoidal approx. 0.036 by 0.026; uterine pore absent. Vitelline follicles forming sleeve encircling reproductive organs.

Remarks

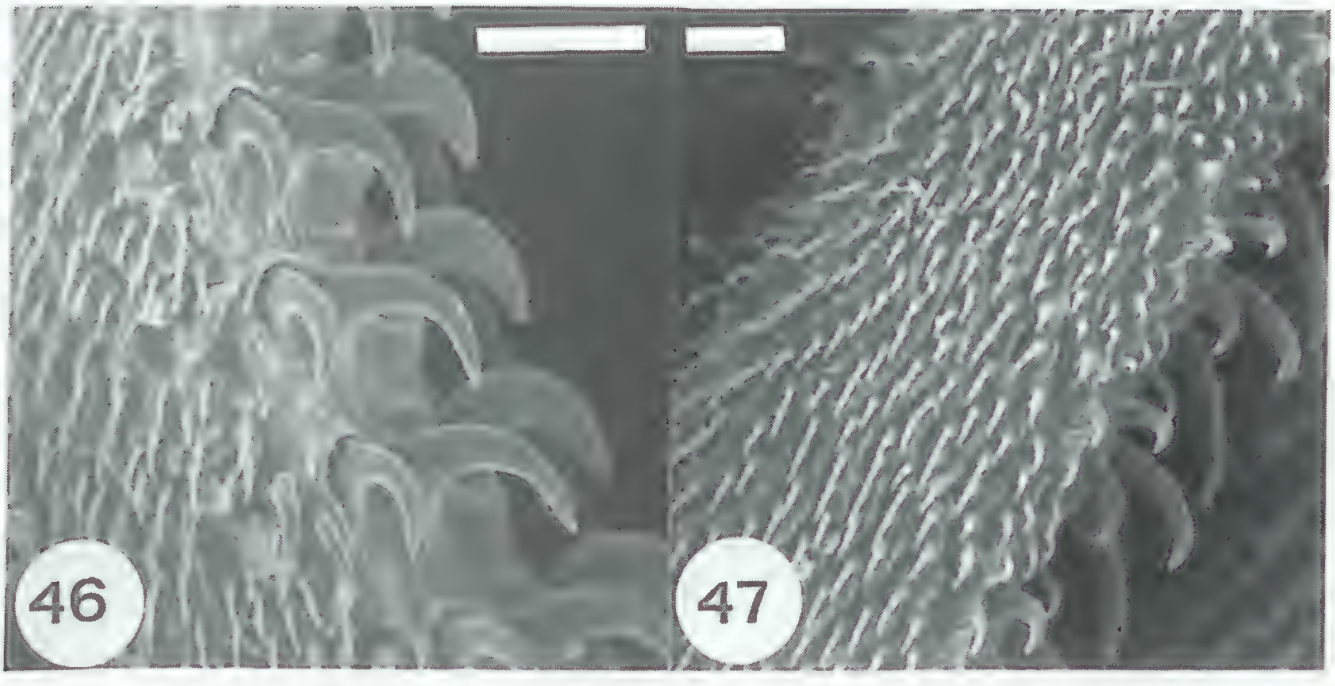
In spite of its cosmopolitan distribution, the anatomy of this species is relatively poorly known. The first report from Australia was that of Robinson (1965), who described plerocerci from *Argyrosomus hololepidotus* (Lacépède, 1802) (syn. *Sciaena antarctica* Castlenau, 1872) from New South Wales. The adult stage had been described earlier by Goldstein (1962, 1963) from American sharks. Robinson (1965) compared his specimens with those of Goldstein (1963). The armature of this species has recently been



FIGURES 33–38. *Poecilancistrium caryophyllum* (Diesing, 1850). Tentacular armature. **33.** Basal and metabasal region, internal surface. **34.** Metabasal region, bothridial surface. **35.** Two principal hook rows showing relationships between intercalary hooks and band of hooklets. **36.** Schematic representation of hook arrangements. Numerals indicate hooks of principal rows, letters are intercalary hooks; circles represent hooklets of external surface. **37.** Basal region, bothridial surface. **38.** Basal and metabasal regions, external surface. Specimens from *Carcharhinus brachyurus* (Guenther, 1870) (AHC 24957). Scale bars: 0.1 mm.



FIGURES 39–45. *Poecilancistrium caryophyllum* (Diesing, 1850). **39.** Scolex. **40.** Bothridium. **41.** Junction of sheath and bulb showing origin of retractor muscle. **42.** Cirrus sac. **43.** Gravid proglottis. **44.** Mature proglottis. **45.** Eggs. Specimens from *Carcharhinus brachyurus* (Guenther, 1870) (AHC 24957). Scale bars: Figures 39, 40, 43, 1.0 mm; Figures 41, 42, 44, 45, 0.1 mm.



FIGURES 46–47. *Poecilancistrium caryophyllum* (Diesing, 1850). Scanning electron micrographs of armature. **46.** Bothridial surface, metabasal region. showing junction of principal rows of hooks with band of hooklets on external surface. **47.** External surface, metabasal region showing band of hooklets. Specimens from *Carcharhinus brachyurus* (Guenther, 1870). Scale bars: 0.1 mm.

redescribed by Palm (1995) based on specimens from Atlantic teleosts.

The present description of the adult provides additional information, in demonstrating the presence of a crescentic internal seminal vesicle, a circular external seminal vesicle adnate to the cirrus sac and in describing the morphology of the gravid uterus.

The most significant aspect of the current redescription is the oncotaxy. Although adequately described by Robinson (1965), the only attempt to interpret the pattern of hooks is that of Campbell and Beveridge (1994) and Palm (1995). The external surface of the tentacle of *P. caryophyllum* is covered by a band of small hooks. The features not noted in previous descriptions are associated with the regularity of arrangement of the small hooks comprising the band. They are arranged in ascending rows, with four between each principal row, and with the ascending rows terminating in the midline of the external surface. Some minor departures from the regular pattern are detectable, with the presence of an occasional hook which does not fit within a row. However, these irregularities are rare, and at the base of the tentacle the hook files form a convergence as seen in typical heteroacanthous armature patterns.

Superfamily POECILACANTHOIDEA Dollfus, 1942

Family LACISTORHYNCHIDAE Guiart, 1927

Genus ***Callitetrarhynchus*** Pinter, 1931

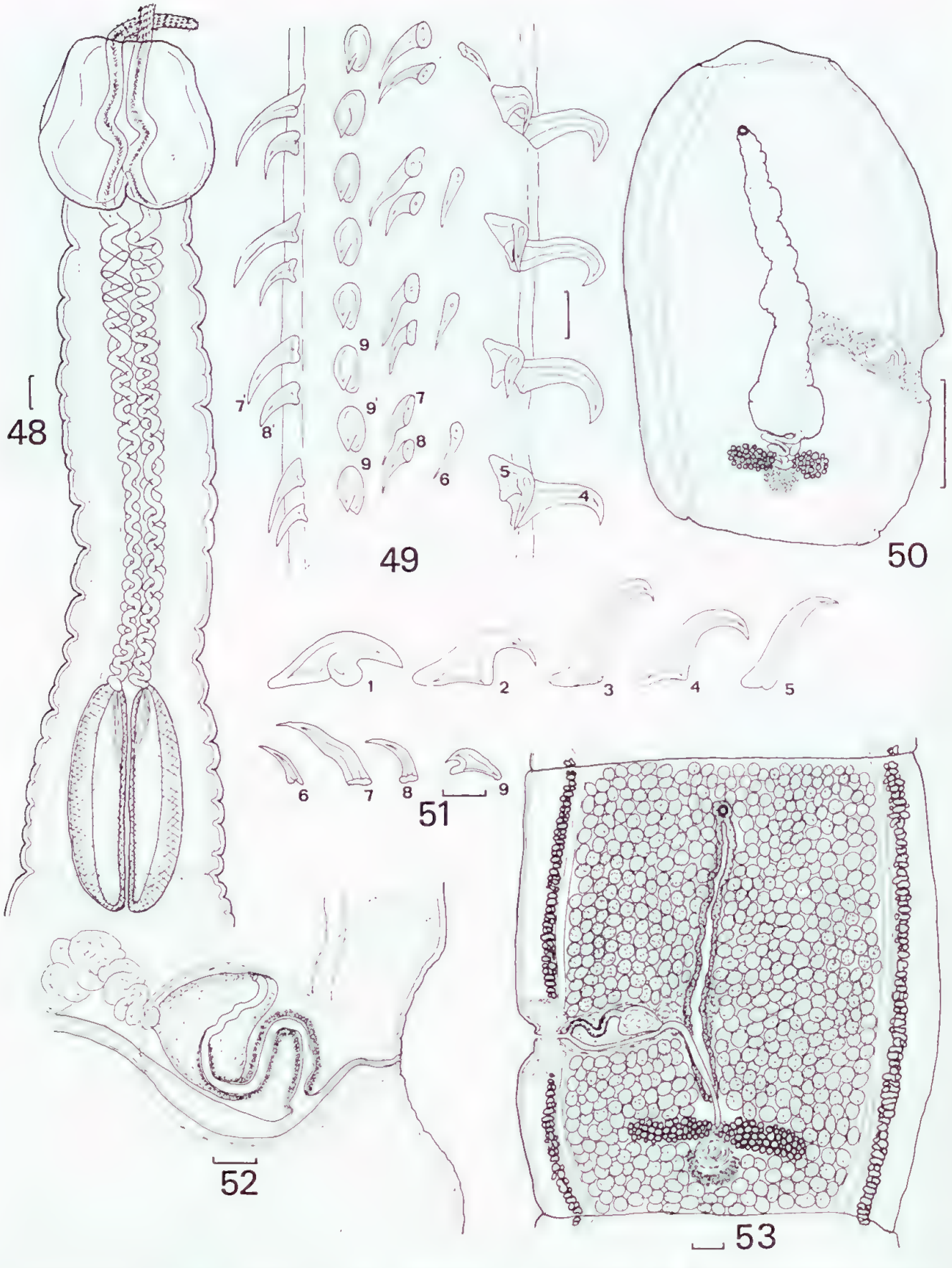
The genus was considered monotypic by Dollfus (1942). However, Carvajal and Rego (1985) have shown that Dollfus' description is a composite of *C. gracilis* and *C. speciosus*. Only *C. gracilis* has been found in Australian fishes to date.

Callitetrarhynchus gracilis (Rudolphi, 1819) (Figs 48 – 53)

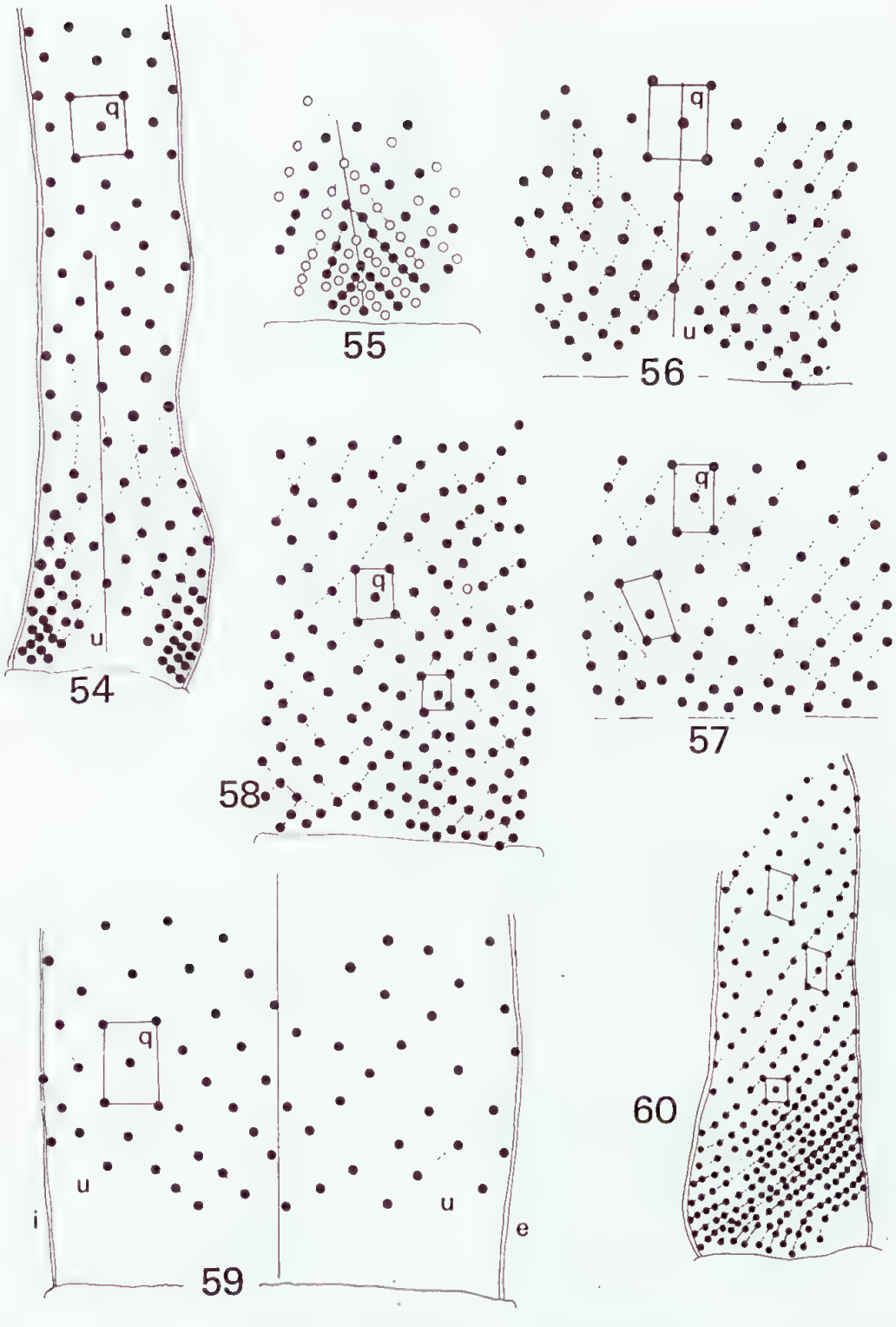
Synonymy — see Dollfus (1942)

Material examined

Adults. From *Carcharhinus amblyrhynchoides* (Whitley, 1934): 1 specimen, Snapper Island, Qld. (AHC 24941). From *Carcharhinus melanopterus* (Quoy & Gaimard, 1824): 3 specimens, Flat Top Island, Qld. (AHC 24940); 1 specimen, Darwin, N.T. (AHC 24939). From *Carcharhinus amboinensis* (Mueller & Henle, 1839): 1 specimen, Mary River, N.T. (AHC



FIGURES 48–53. *Callitetrarhynchus gracilis* (Rudolphi, 1819). **48.** Scolex. **49.** Tentacular armature, metabasal region, external surface. **50.** Gravid proglottis. **51.** Profiles of hooks 1–9. **52.** Terminal genital ducts showing cirrus and vagina uniting within 'cirrus sac' to form a short hermaphroditic duct. **53.** Mature proglottis. Specimens from *Carcharhinus fitzroyensis* (Whitley, 1943) (AHC 24937). Scale bars: Figures 48, 52, 53, 0.1 mm; Figures 49, 51, 0.01 mm; Figure 50, 1.0 mm.



FIGURES 54–60. Schematic arrangements of hook patterns. **54.** *Tentacularia coryphaenae*. Basal and metabasal regions, internal surface, showing ascending hook rows and V-shaped unarmed area (u) at base of tentacle. Hooks of metabasal region are arranged in quincunxes (q). Derived from Fig. 2. **55.** *Tentacularia coryphaenae*. Basal region bothridial surface (from Fig. 3), showing ascending rows of hooks. **56.** *Hepatoxylon trichiuri*. Basal and metabasal regions, internal surface (from Fig. 19), showing V-shaped unarmed area at base of tentacle (u) and quincunxial arrangement of hooks (q) in metabasal region. **57.** *Hepatoxylon trichiuri*. Basal and metabasal region, bothridial surface, showing quincunxial hook arrangement (q) (from Fig. 20). **58.** *Hepatoxylon megacephalum*. Basal and metabasal region, internal surface (from Fig. 24) showing quincunxial hook arrangement (q). **59.** *Hepatoxylon megacephalum*. Basal region, bothridial surface, showing ascending hook rows which form V-shaped unarmed areas (u) on internal (i) and external (e) surfaces and quincunxial hook arrangement (q). **60.** *Sphyriocephalus tergestinus*. Oblique view with bothridial surface to left (from Fig. 30) showing hooks arranged in ascending spiral rows in typical heteroacanthous pattern.

24938). From *Carcharhinus fitzroyensis* (Whitley, 1943): 6 specimens, Darwin N.T., (AHC 24937); 5 specimens, Mary River, N.T (AHC 24936). From *Dasyatis fluviorum* Ogilby, 1908: 1 specimen, Moreton Bay, Qld. (AHC 24942).

Metacestodes. From *Sphyraena novaehollandiae* Günther, 1860: Brighton, S.A. (AHC S539); Outer Harbour, S.A. (BMNH 1986. 10.1.2). From *Pristipomoides multidens* (Day, 1870): 1 specimen, Bathurst Island. N.T. (AHC 24943). From *Makaira indica* (Cuvier, 1832): 1 specimen, Cape Bowling Green, Qld. (AHC 17410); 5 specimens, Pixie Reef, Cairns, Qld. (AHC 17417). From *Makaira mazara* (Jordon & Snyder, 1901): 1 specimen, Cape Moreton, Qld. (QM G212785). From *Istiophorus platypterus* (Shaw & Nodder, 1791): 3 specimens, Cape Moreton, Qld. (AHC 18496); 2 specimens, Beaver Cay, Qld. (AHC 18495). From *Euthynnus affinis* (Cantor, 1849): 1 specimen, Cape Moreton, Qld. (AHC 18493). From *Saurida tumbil* (Bloch, 1795): 1 specimen, Moreton Bay, Qld. (Coll. RJGL). From *Scomberomorus commerson* (Lacépède, 1800): 1 specimen, Pt Lookout, Qld. (Coll. RJGL). From *Scomberomorus munroi* Collette & Russo, 1980: 3 specimens, Amity Pt, Qld. (Coll. RJGL). From *Platycephalus fuscus* Cuvier, 1829: 1 specimen, Moreton Bay, Qld. (QM G212172). From *Arripis trutta* (Bloch & Schneider, 1801): 3 specimens, Phillip Island, Vic. (AHC 24944). From *Arripis truttaceus* (Cuvier, 1829): 1 specimen, Phillip Island, Vic. (AHC 24945).

Remarks

This cosmopolitan species has previously been reported from Australia only by Prudhoe (1969) from *Platycephalus bassensis* Cuvier, 1829 from Tasmania and by Adjei *et al* (1986) from *Saurida tumbil* (Bloch, 1795) and *S. undosquamis* (Richardson, 1848) from Queensland. The identification of the Queensland specimens was confirmed, however, the Tasmanian specimens (SAM V604) on re-examination proved to be *Floriceps minacanthus* Campbell & Beveridge, 1986, and have not therefore been included in the list of material examined. The scolex and armature of *C. gracilis* were well described by Dollfus (1942) but unfortunately, the description was a composite of *C. gracilis* and *C. speciosus*. The scolex and armature of both species were illustrated and described by Carvajal and Rego (1985). The adult was described very briefly under the name *Tentacularia pseudodera* by Shuler (1938). A more complete description was provided by Subhapradha (1955). It is clear from Subhapradha's figures of the armature that the specimens described are indeed *C. gracilis* rather than *C. speciosus*, since hooks 7(7') are much longer than hooks 8(8'). However, Subhapradha's (1955) description needs to be amended at three points. Firstly, a muscular pad surrounds the genital atrium (Fig. 53). This very prominent feature was not mentioned or illustrated by Subhapradha (1955). Secondly, an hermaphroditic duct is present (Fig. 52). The vagina enters the cirrus sac (actually an hermaphroditic sac) on its medio–ventral aspect then runs within the sac the join with the cirrus leaving a short hermaphroditic duct to enter the genital atrium. The presence of a hermaphroditic duct was first reported by Beveridge and Campbell (1989) and was illustrated by them subsequently (Campbell & Beveridge 1994). All known genera with chainettes and two bothridia have hermaphroditic ducts (Beveridge & Campbell 1989). Thirdly, a uterine pore is present. This feature was not included in the generic diagnosis given by Campbell and Beveridge (1994).

Acknowledgments

We wish to thank all those who have made specimens available to us, either from their own collections or from collections in their care, particularly L. R. G. Cannon, M. Cappo, T: Cribb, F. Hoedt, R. J. G. Lester, B. Robertson, K. Sewell, P. Speare, D. M. Spratt, R. A. Bray & P. M. Thomas.

This project was supported financially by the Australian Biological Resources Study.

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THE GENUS *SELENARIOPSIS* MAPLESTONE, 1913 (BRYOZOA, ASCOPHORINA)

P. E. BOCK & P. L. COOK

BOCK, P. E. & COOK, P. L. 1996. The Genus *Selenariopsis* Maplestone, 1913 (Bryozoa, Ascophorina) *Records of the South Australian Museum* **29**(1): 23–31.

Lunulitiform colonies of *Selenariopsis* are a frequent component of the microfauna inhabiting the surface and upper layers of the deeper shelf sediments off the southern and eastern coasts of Australia. Colonies are anchored by rhizoids originating from special porous areas on the exposed basal walls. Although colonies are fragile, fragmented specimens are present as fossils in the clay-rich marine Tertiary sediments of Victoria and South Australia. Tertiary colonies include two taxa, *S. macgillivrayi* sp. nov. and *S. marginata* sp. nov., both of which are distinct from the Recent form, *S. gabrieli* Maplestone, 1913. Full descriptions and a key to all three species are given below.

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The distinctive 'sand fauna' species *Selenariopsis gabrieli* Maplestone, 1913 has been reported several times from the coasts of New South Wales, Western Australia and South Australia, as well as from Bass Strait. Colonies live in or upon the upper layers of sediment and have been reported previously from 54–366 m deep (see Cook & Chimonides 1981a, and Wass & Yoo 1983). Colonies are lunulitiform and live anchored by large basal rhizoids. *Selenariopsis* has been reported from the Tertiary of Victoria, as *?Lunulites angulopora* by MacGillivray (1895), and this record has usually been included in the synonymy of *S. gabrieli*, the Recent form (see Powell 1966; Cook & Chimonides 1981a). Examination of Recent specimens of *S. gabrieli*, and analysis of numerous Tertiary samples from Victoria and South Australia has revealed the presence of two additional species neither of which is *S. gabrieli*. One appears to be the *?Lunulites angulopora* of MacGillivray (1895), the other is described for the first time below.

Materials And Methods

Abbreviations of institutions referred to in this paper are: MV, Museum of Victoria, Melbourne; AM, Australian Museum, Sydney; SAM, South Australian Museum, Adelaide. Specimens were coated with gold for scanning electron microscopy.

Systematics

Order Cheilostomatida Busk, 1852

Suborder Ascophorina Levinsen, 1909

Super Family CATENICELLOIDEA Busk, 1852

Family EURYSTOMELLIDAE Levinsen, 1909

Cook and Chimonides (1981a) referred *Selenariopsis* to an informal grouping of genera, the Gymnocystidean Ascophora, based on the nature of the calcified frontal shield. Relatively few genera are known to have gymnocystidean ontogeny, and these are not closely related systematically to one another. Several gymnocystidean genera have been discussed by Gordon (1984, 1989), and referred to different superfamilies.

The affinities of the Eurystomellidae are somewhat problematical. *Eurystomella bilabiata* (Hincks) and *Selenariopsis gabrieli* Maplestone have completely non-porous, gymnocystidean frontal shields, the only areas of cryptocyst occurring as proximo-lateral embayments at the edges of the orifice, which appear to be associated with the hinging of the operculum (see Cook & Chimonides 1981a). *E. foraminigera* (Hincks) has, however, a shield with large, cuticle-covered, cryptocyst-bordered foramina (see Cook & Chimonides 1981a and Gordon 1984). The

1

3

2

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ovicells of all three species are endozooidal, the brooding zooid having an enlarged, dimorphic orifice, which in *S. gabrieli* is closed by the operculum. The ovicell cavities are associated with a distal autozooid or kenozooid. The frontal ectooecium has one or more areas of cuticle–covered entooecium and a median suture. There are similarities in both frontal shield and ovicell structure with some members of the family Catenicellidae (see Banta & Wass 1979 and Wass & Banta 1981). Gordon (1984, 1989) has included the Eurystomellidae with the Catenicellidae in the superfamily Catenicelloidea.

Genus *Selenariopsis* Maplestone, 1913

Selenariopsis Maplestone, 1913: 359; Cook & Chimonides, 1981a: 114.

Australiana Powell, 1966: 19.

Diagnosis

Colonies lunulitiform, budded radially. Zooids with imperforate, gymnocystidean frontal shields and sinuate primary orifices. Basal walls with uncalcified windows and porous areas which are the origin of rhizoids in Recent colonies. Ovicells with dimorphic orifice, closed by the operculum, with paired entooecial areas frontally. Avicularia absent.

Key To Species

1 – Orifices elongated, raised marginally. Ovicell fairly prominent, followed by an autozooid, with extensive, but faintly marked, paired entooecial areas. Basal porous areas usually very small .... *S. marginata* sp. nov.

– Orifices not raised marginally; basal porous areas larger 2

2 – Autozooid frontals oblong. Orifice with a subtriangular sinus. Ovicell depressed distally, followed by an autozooid. Small paired entooecial areas close to median suture. Basal windows very narrow .... *S. macgillivrayi* sp. nov.

– Autozooid frontals almost square. Orifice with a wide rounded sinus. Ovicell wide, immersed in a distal kenozooid with paired distal fenestrae. Basal windows oval .... *S. gabrieli* Maplestone

Selenariopsis gabrieli Maplestone, 1913
(Figs 1, 7)

Selenariopsis gabrieli Maplestone, 1913: 359, pl. 28, figs 6–10; Cook & Chimonides 1981a: 114, Figs 2D, 3, 4E, 5A–C, 9C; Wass & Yoo 1983: 337, Figs 44–46.

Australiana bifenestrata Powell, 1966: 20, pl. 1, figs 1–7, Fig. 1a–i; Cook 1979: pl. 1, figs 12d, e, Fig. 1F.

Material Examined

AM Gabo Island, Victoria, 366 m. MV Kimbla Stn 65D, Bass Strait, 207 m. Kimbla Stn 99, Bass Strait, 139 m. SLOPE Stn 19, off Eden, New South Wales, 520 m. Slope Stn 45, off Freycinet Peninsula, Tasmania, 800 m. Great Australian Bight Stn 030, 33°13'S, 128°29'E, 137 m.

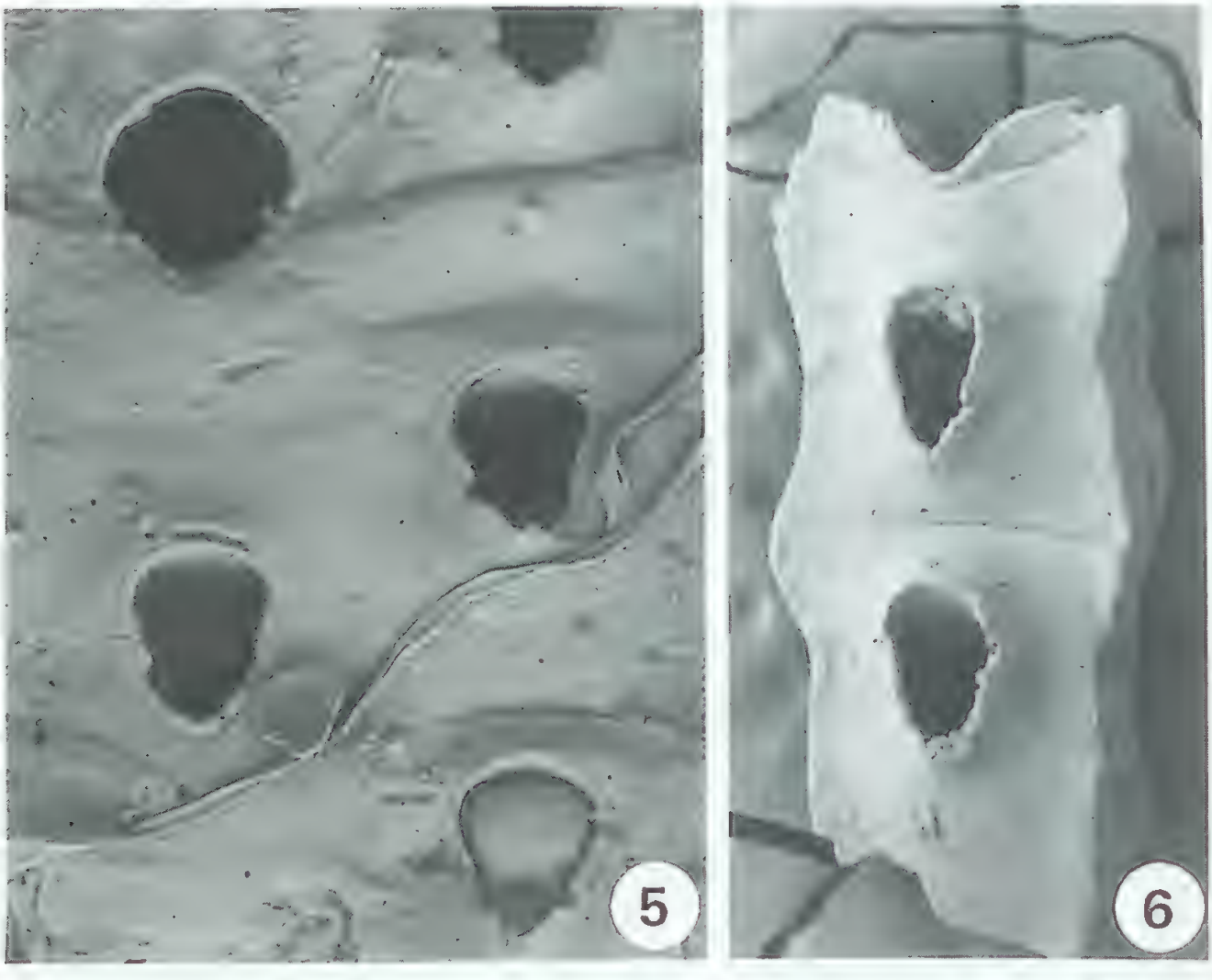
Description

Autozooid with short, almost square frontal shield, orifice nearly central with a short, rounded sinus marked by minute lateral embayments of cryptocyst. Brooding orifice wide, almost semi-circular. Ovicell wide, not prominent, immersed in a distal kenozooid with large, paired, subtriangular entooecial fenestrae on its frontal surface. Basal autozooid windows oval or slightly narrower; those of brooding zooids are very large and subtriangular. The rhizoid windows are a narrow crescent, with a large proximal porous area surrounded by a raised rim. Pores are placed round the edge of the large, rounded to subrectangular area; the rhizoids are large.

Distribution

A. bifenestrata was described by Powell (1966) from Bulgo and from several other New South

◀ FIGURES 1–4. **1**, *Selenariopsis gabrieli* Maplestone, Kimbla Stn 99. Autozooids and one brooding zooid with paired distal kenozooidal frontal fenestrae; note 'growth lines', X118; **2**, *S. macgillivrayi* sp.nov., Princetown. Autozooids and one brooding zooid with inconspicuous distal ovicell with paired frontal areas (arrowed), X110; **3**,**4**, *S. marginata* sp.nov., Princetown; **3**, Brooding zooid with ovicell, frontal areas arrowed; and two autozooids, one showing proximo–lateral embayments (arrowed), and subtriangular sinus, X80; **4**, Brooding zooid with ovicell, X80.



FIGURES 5–6. **5**, *Selenariopsis macgillivrayi* sp.nov., Princetown. Autozooid orifices and one brooding zooid; note 'growth line', X110; **6**, *S. marginata* sp.nov., Princetown. Two autozooids showing raised orifices and lateral septular pores, X80.

Wales localities. The records given by Wass and Yoo (1983) extend from Western Australia, near Albany through the Bight to the western end of Bass Strait. The other records given above include one from the Great Australian Bight, and also extend from Bass Strait east to New South Wales, and south to Tasmania. Recorded depths now range from 54 to 800 m.

Remarks

Colonies may reach a diameter of more than 5 mm, and 3.50 mm in height, although the vertical dimension is variable, some colonies being fairly flattened, while others are strongly domed, as illustrated by Powell (1966). Rhizoids are 0.25 mm wide, and may reach more than 3 mm in length; even small colonies usually have several present. The ancestrula has an uncalcified frontal wall and a large, prominent basal pore plate giving rise to a rhizoid. Brooding zooids are scattered and do not appear before the fourth astogenetic generation. Frontally , the surface of colonies is smooth, even the ovicells hardly protruding. The morphology has been described in great detail by Powell (1966), and the mode of life and the associated fauna in one sample was discussed by Cook (1979). The early astogeny and relationships were described by Cook and Chimonides (1981a). *S. gabrieli* differs from its two fossil congeners in the shape of the orifice, and the structure and relationships of the ovicell.

***Selenariopsis macgillivrayi* sp. nov.**
(Figs 2, 5, 8)

?*Lunulites angulopora* MacGillivray, 1895: 46, pl. 8, fig. 1 (not *L. angulopora* Tenison Woods, 1880 = *Conescharellina angulopora*).

Material Examined

Holotype: MV P27625, Muddy Creek, Victoria,

Miocene (see Powell 1966); also material from Cooriemungle, Balcombe Bay, Grices Creek, Princetown, Gellibrand Clay, Mount Martha, Victoria and Mount Schanck, South Australia (SAM P35472).

Description

Autozooids with almost oblong frontal shield, orifice placed in the distal half, slightly elongated, with a subtriangular sinus. The lateral embayments are very small, reduced to paired notches on the edge of the orifice. The brooding zooid orifice is wide and rounded. The ovicell is almost flat, and the next distal zooid is often crossed by a depressed groove in the calcification. The paired entooecial areas are small and not obvious; they are usually placed close to the median suture. The basal autozooid windows are very narrow, those of brooding zooids are more oval. The rhizoid windows are crescentic, with a large rounded proximal porous area within a raised rim. Pores are placed round the edge of the area.

Etymology

Named for P. H. MacGillivray, who first described the fossil specimens.

Distribution

S. macgillivrayi occurs in Miocene deposits from Mount Schanck in South Australia in the west to the east coast of Port Phillip Bay in Victoria.

Remarks

MacGillivray (1895) was doubtful that his specimen was the same species as that described as *Lunulites angulopora* by Tenison Woods (1880), but did not discuss his reasons. Two of Tenison Woods's species of 'Selenariadae', *L. crassa* and *L. angulopora*, are not lunulitiform and free-living, but belong to the genus *Conescharellina*. The name '*angulopora*' is not available for *Selenariopsis* and MacGillivray's species is therefore renamed here. MacGillivray gave no locality for his specimen, which consisted of two fragments only. As mentioned by Powell (1966) the specimens are labelled 'Muddy Creek'. MacGillivray considered that the basal rhizoid window and porous area was the zooid orifice, and that the orifices on the other side of the fragments were 'probably avicularian'. Without the advantage of having complete colonies for examination, the basal and frontal surfaces do look remarkably alike. Both have smooth calcification marked into rectangles by vertical zooid walls. The more oval basal windows and slightly worn orifices appear to be extremely similar, to superficial inspection, and it is easy to understand how MacGillivray made the wrong interpretation.

The specimens examined here are also all fragmentary, and are generally rare, although present at a large number of localities. More than 70 fragments, the largest of more than 50 zooids, are present in the sample from Princetown, and are accompanied by *S. marginata* sp. nov.

S. macgillivrayi differs from *S. gabrieli* in the more elongated shape of the orifice, and the slightly smaller and rounder basal porous areas. The principal difference is that the zooid distal to the ovicell is an autozooid, not a kenozooid, and the entooecial areas are placed close to the median suture, on the frontal surface of the ovicell. *S. macgillivrayi* differs from *S. marginata* sp. nov. in the size of zooids, and the shape and size of zooid orifices. The basal porous areas are larger and the basal windows narrower.

Selenariopsis marginata sp. nov.
(Figs 3, 4, 6, 9, 10)

Material Examined

Holotype: MV P140966, Princetown, Miocene.

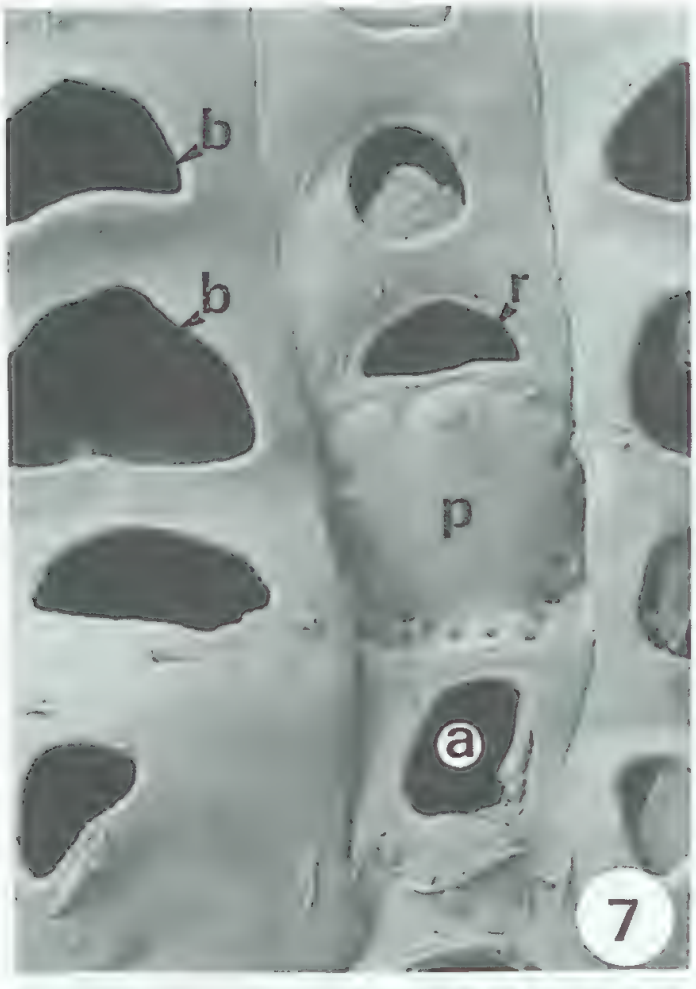
Paratype material: Princetown and Balcombe Bay, Victoria, Miocene (SAM P35471).

Description

Autozooid frontal shields large, short and wide, often almost square. Orifices nearly central, large, marginally raised, elongated, with a subtriangular sinus and minute lateral embayments only visible in well preserved specimens. The brooding zooid orifice is wide and rounded with a subtriangular sinus. The ovicell is more prominent than that of *S. macgillivrayi*, and distinctly narrower than both the brooding zooid and distal autozooid. The frontal areas are often not obvious, but when present, are placed well away from the median suture on the ovicell frontal wall. The basal windows of autozooids and brooding zooids are oval or nearly circular. The basal rhizoid windows are usually small, and are sometimes more subtriangular than crescentic; the porous area is also very small, sometimes minute, and is circular, with a raised rim and scattered pores.

Etymology

Marginatus. L., enclosed with a border, referring to the raised rims of the zooidal orifices.


b
b
r
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a
7

p
9

p
8

p
10

Distribution

Miocene of Victoria.

Remarks

S. marginata is represented by fewer than 60 fragments, the largest of only 8 zooids, but its characters are distinct and consistent. The dimensions of zooids appear to be generally much larger than those of the other two species, at the inferred equivalent astogenetic stage.

S. marginata is distinguished from both *S. gabrieli* and *S. macgillivrayi*, with which last it often occurs, by the raised margins of the elongated orifices. These may be so prominent that they make the colony surface appear to be rugose. The other obvious difference is the small size of the basal porous areas. The ovicell is less depressed than that of *S. macgillivrayi*, which it resembles in having a distal autozooid, unlike the kenozooid of *S. gabrieli*.

Discussion

Although no complete colony of *Selenariopsis* has been preserved as a fossil, it is remarkable that such delicate species have been found in fragments large enough to be recognizable, and distinguishable from each other. The slight curvature and the budding pattern of the fragments allow the inference that they had a lunulitiform shape when complete. The occurrence of the distinctive windows and porous areas on the basal side of the fossils allows the inference that they, too, developed rhizoids in life, and lived in a similar manner to *S. gabrieli*. The larger fragments of *S. macgillivrayi* show ridges frontally between zooid generations and 'growth lines' in the calcification of the frontal shields (Fig. 5). These also occur in colonies of *S. gabrieli*, where they appear to be related to episodes of repair, and of 'seasonal growth', and to rapid calcification of the frontal membranous wall of zooid buds (Fig. 1).

The differences among the three species of *Selenariopsis* are small, but in several characters, the states are distinct and consistently correlated (Table 1). *S. gabrieli* resembles *S. macgillivrayi* in many ways and may be a direct descendant. *S. marginata* differs from both species in zooid size and the raised margins of the elongated autozooid orifices, as well as in the very small basal porous areas.

It is interesting that the Recent species, *S. gabrieli*, exhibits two features which indicate a closer relationship with the genus *Eurystomella* than with its fossil congeners. The cryptocyst embayments at the edge of the orifice, although small in *S. gabrieli*, are distinct; in the fossil species they are much smaller, and can often hardly be distinguished. Further, in *S. gabrieli* and all species of *Eurystomella*, the kenozooid which completely envelops the distal end of the ovicell capsule also bears the entooecial window or fenestrae on its frontal wall.

In *S. macgillivrayi* and *S. marginata* the entooecial areas are part of the frontal wall of the ovicell capsule, not the distal autozooid, which surrounds the capsule on the basal side only. A

TABLE 1. Measurements in mm of species of *Selenariopsis*. Lz, lz, length and width of autozooid; Lo, lo, length and width of orifice; L bro, l bro, length and width of brooding zooid orifice; Lov, lov, length and width of ovicell; Lbw, lbw, length and width of basal window; Lrw, lrw, length and width of rhizoid window; Lpa, lpa, length and width of porous area.

Character	*S. gabrieli*	*S. macgillivrayi*	*S. marginata*
Lz	0.30–0.44	0.30–0.45	0.37–0.66
lz	0.25–0.40	0.25–0.40	0.36–0.48
Lo	0.11–0.16	0.13–0.18	0.18–0.25
lo	0.10–0.12	0.10–0.13	0.12–0.16
L bro	0.11–0.13	0.16–0.18	0.15–0.17
l bro	0.16–0.18	0.16–0.19	0.14–0.16
Lov	0.08–0.10	0.18–0.23	0.25–0.30
lov	0.21–0.24	0.22–0.32	0.30–0.40
Lbw	0.16–0.22	0.20–0.21	0.17–0.24
lbw	0.12–0.15	0.02–0.06	0.12–0.14
Lrw	0.10–0.12	0.08–0.09	0.08–0.10
lrw	0.20–0.23	0.14–0.18	0.10–0.16
Lpa	0.18–0.25	0.20–0.25	0.08–0.16
lpa	0.16–0.25	0.17–0.25	0.08–0.18

◀ FIGURES 7–10. **7**, *Selenariopsis gabrieli* Maplestone, Kimbla Stn 99. Basal walls, showing uncalcified windows of brooding zooids and ovicells (*b*), autozooids (*a*), and one rhizoid window (*r*). Large, subrectangular porous area with marginal pores (*p*), X100; **8**, *S. macgillivrayi* sp.nov., Princetown. Narrow basal windows of autozooids and one rhizoid window with proximal porous area (*p*), X80; **9–10**, *S. marginata* sp.nov., Princetown. Distal autozooid, and proximal rhizoid basal windows; note small, circular porous areas (*p*). Fig. 9, X80; Fig. 10, X100.

parallel series of differing relationships in time, among the brooding zooids, ovicells and distal zooids occurs in species of the Australian Tertiary–to–Recent genus *Quadriscutella* (see Bock & Cook 1993).

The cuticle–covered basal window of each zooid of *Selenariopsis* has a parallel in the ascophoran genera *Chiastosella* and *Didymosella*. Both these genera have a wide Tertiary–to–Recent geographic range, and are particularly well represented in Australasia. Although many species have a semi-repent, unilaminar colony form, none is lunulitiform. Powell (1967:285) noted that colonies of *Chiastosella splendida* were attached by basal rhizoids, but the only description of the basal windows was given by Waters (1881:340) in fossil specimens of *C. conservata* from Victoria. The basal windows of *Didymosella larvalis* were described by Cook and Chimonides (1981b); they do not give rise to any rhizoids, but in *D. pluma*, a South American species, they may be produced into long, hollow, extrazooidal calcified processes.

Many of the reports of *S. gabrieli* have been from fairly deep shelf, and upper slope depths, the two deepest among the samples listed above being from 520 and 800 m. The associated bryozoans from these samples include many with cellulariiform, erect colonies, all anchored by rhizoids (see Bock & Cook in press). Species found in association with *S. gabrieli* at the shallower end of the depth range have been discussed by Cook (1979), and included forms of *Melicerita*, *Sphaeropora* and *Conescharellina*. These too, are anchored by rhizoids. Specimens of these three genera are robust, and are often preserved entire as fossils as well as occurring in Recent sediments. Some colonies of *Conescharellina*, and of the free–living lunulitiform genera *Lunulites*, *Lunularia* and *Selenaria* all occur in the Princetown samples. There is, however, no correlation of numerous sand fauna taxa in association with the two fossil species of *Selenariopsis*, and certainly no suggestion that the assemblage was from very deep water.

Acknowledgments

We should like to thank the Museum of Victoria and Australian Museum for access to collections, and D. McDonald for help in preparation of this paper.

Appendix

Details of Tertiary Localities in Victoria and South Australia.

Balcombe Bay: Also known as **Fossil Beach, Mornington, Mount Martha** and possibly **'Schnapper Point'** (MacGillivray); on coast of Port Phillip Bay, about 3 km south of Mornington, Victoria. Lat. 38°14.5'S, Long. 145°01.7'E. Fyansford Clay. Age: Balcombian; Middle Miocene, (Langhian).

Cooriemungle area: Road cuttings about 18 km north of Princetown. Lat. 38°32.4'S, Long. 143°08.1'E. Gellibrand Marl. Age: Balcombian.

Gellibrand. This locality was mentioned by MacGillivray (1895), and is in the same area as **Princetown** (see below).

Grices Creek: Also known as **Gunyong Creek**; on coast of Port Phillip Bay, about 8 km north of Mornington, Victoria. Lat. 38°11.9'S, Long. 145°03.9'E. Fyansford Clay. Age: Balcombian (some material may be Bairnsdalian); Middle Miocene, (Langhian).

Mount Schanck: Limestone quarry about 1 km west of Mount Schanck, about 15 km south of Mount Gambier, South Australia. Lat. 37°57'S, Long. 140°43.2'E. Gambier Limestone. Age: Longfordian; Early Miocene.

Muddy Creek: Clifton Bank, Muddy Creek, 8 km west of Hamilton, Victoria. Lat. 37°44.6'S, Long. 141°56.4'E, Muddy Creek Marl (= Gellibrand Marl). Age: Balcombian.

Princetown (*Gigantocypraea* locality): Coastal section, about 2 km west of Princetown, Victoria. Lat. 38°41.9'S, Long. 143°08.3'E, Gellibrand Marl. Age: Balcombian.

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COELOPLANA SCABERIAE SP. NOV., A NEW BENTHIC CTENOPHORE (CTENOPHORA: PLATYCTENIDA: COELOPLANIDAE) FROM SOUTH AUSTRALIA

G. I. MATSUMOTO & K. L. GOWLETT-HOLMES

MATSUMOTO, G. I. & GOWLETT-HOLMES, K. L. 1996. *Coeloplana scaberiae* sp. nov., a new benthic ctenophore (Ctenophora: Platyctenida: Coeloplanidae) from South Australia. *Records of the South Australian Museum* **29**(1): 33–40.

A new species of benthic ctenophore, *Coeloplana scaberiae* sp. nov., is described from South Australia, and some preliminary observations on the behaviour and abundance of this new species are presented. The new species can be distinguished from other species in the genus by its bright red or orange colour and its specific host plant, the brown alga *Scaberia agardhii* Greville. This is the fourth record of benthic ctenophores from Australia.

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Manuscript recieved 30 August 1995.

Members of the Phylum Ctenophora have the potential to impact ecosystems to a considerable extent (Carlton & Geller 1993), yet research on this group has been relatively sparse because of the difficulties in collecting specimens. Within this phylum there are currently seven orders, one of which (Platyctenida) are benthic in habit. There are four families within this order and approximately 40 species. The platyctenes are unusual in that they are benthic, they have lost (secondarily) the characteristic ctene rows, and are capable of both sexual and asexual reproduction (Harbison & Madin 1982). Their ability to reproduce both sexually and asexually is unique among the ctenophore phylum and can often result in extremely high densities. A species of platyctene in Hawai'i reaches densities of over 3000 individuals/square meter (C. P. Galt, pers. comm.). Platyctenes range in distribution from tropical (Arnold 1993) to polar (Dayton & Robilliard 1972) waters, and can be found living on various hosts, including ascidians, hydroids, asteroids, echinoids, and algae. Many species of platyctenes look similar to platyhelminths when preserved and may be found in collections labelled as such.

There are only three previous records of platyctenes from Australian waters (Stephenson *et al.* 1931, Smith & Plant 1976, Arnold 1993). Stephenson *et al.* (1931) describe the presence of *Coeloplana* sp. on the Great Barrier Reef but give no specific identification. Smith and Plant (1976) describe specimens (Museum of Victoria, G2649) tentatively identified as *Coeloplana willeyi* collected from 15.5 m depth with green algae (*Caulerpa* sp) and unidentified red algae at the southern end of Port Phillip Bay, Victoria. Arnold (1993) collected specimens (Queensland Museum, G35888) of *Coeloplana meteoris* from Pioneer Bay, Orpheus Island from soft substrate at 12–13 m depth. W. M. Hamner collected specimens of planktonic transparent *Ctenoplana* off of Townsville but has not published these observations (pers. comm.).

Recently, some strikingly coloured animals living in association with the brown alga *Scaberia agardhii* Greville, 1830, previously thought to be platyhelminths, have been identified as an undescribed species of platyctene. This paper presents a description and some preliminary observations on the behaviour and abundance of this new species. This new species is confined to small populations on *Scaberia agardhii* in the shallow subtidal. As *Scaberia agardhii* is endemic to southern Australia we postulate that the new species of platyctene is also likely to be endemic to this region. Further work on this species and related species is in progress.

Materials And Methods

The material reported here is deposited in the South Australian Museum, Adelaide (SAM), the

Australian Museum, Sydney (AM), the Museum of Victoria, Melbourne (MV), the Queensland Museum, Brisbane (QM), the Western Australian Museum, Perth (WAM), and the California Academy of Sciences, San Francisco (CAS). All material was fixed and preserved in 2% formaldehyde/propylene glycol solution in sea water, with the exception of one lot (SAM XH0010), which was fixed and preserved in 70% alcohol for later DNA extraction.

The ctenophores were first observed in the field using SCUBA equipment. Photographs were taken in the field with Nikonos III cameras with UW Nikkor 28 mm and UW Nikkor 35 mm lenses, Sea & Sea extension tubes, and Ikelite strobes, and in the laboratory with a Nikon F2 with a Nikkor 55 mm macro lens and strobes. Living specimens were collected by hand and transported back to the laboratory in aerated containers. Fragments of the host alga, *Scaberia agardhii*, were also collected and transported with the ectocommensal ctenophores intact. Colour transparencies (Photo index PH0141–4, PH0184) of the in situ specimens are held in the Photoindex collection of the Marine Invertebrates Section of SAM. Colour description of the new species follows Kornerup and Wanscher (1978).

Specimens used for examination under the scanning electron microscope (SEM) were dehydrated (in a sequential ethanol series) to 100% ethanol, critical point dried, and coated with gold. They were photographed using a Cambridge Mark III SEM.

Systematics

Order Platyctenida Mortensen, 1912

Diagnosis

Body with a pair of conspicuous tentacles; body solid, greatly compressed in the oral/aboral axis, oral portion everted to form a creeping sole. Ctene rows usually greatly reduced or absent in adults. Many species are ectocommensals.

Family COELOPLANIDAE Willey, 1896

Diagnosis

Creeping or sessile ctenophores, ctene rows absent in adults. Tentacles, with tentilla, retractable into sheaths. Meridional canals branched and anastomosed. Pharynx permanently everted; statocyst present and aboral; body length < 6 cm.

Genus *Coeloplana* Kowalevsky, 1880

Diagnosis

With the features of the family.

Remarks

In addition to the new species described below, there are 22 other species of *Coeloplana* described between 1880 and 1970, some of which have been well documented (e.g. *C. willeyi*) and others of which are known only from fragments (e.g. *C. bannwarthi*). The majority of the described species are host-specific and have distinctive colours and patterns.

Coeloplana scaberiae sp. nov.

(Figs 1–3)

Material Examined

Holotype. SAM H843 (PH0143), found on the brown alga *Scaberia agardhii*, in 3–4 m depth, Edithburgh, Yorke Peninsula, Gulf St. Vincent, South Australia (35°5'S, 137°41'E), collected by K. L. Gowlett-Holmes 7 January 1994.

Paratypes. SAM H844 (PH0143) (19), AM G15606(2), MV F75050 (2), QM G305828 (2), CASIZ 104015(2), all same collection data as holotype; SAM H845 (PH0184) (2), same collection data as holotype except for date, 12 June 1994; SAM H846 (PH0141 (18), same collection data as holotype except for water depth, 4–5 m, and date, 3 January 1992; SAM H847 (PH0142) (15), WAM 3–95 (2), same collection data as holotype except for date, 18 May 1992; SAM H848 (PH0144) (85 + fragments), from on the brown alga *Scaberia agardhii*, in 3–4 m depth, Point Turton Jetty, Yorke Peninsula, Spencer Gulf, South Australia, collected by K. L. Gowlett-Holmes 2 April 1994.

Other material. SAM XH0010, same collection data as holotype, alcohol-fixed specimens.

Description

The following description is based on field and laboratory observations of both living and preserved specimens.

Platyctenes to at least 25 mm in length; solid dark orange or vivid red in colour without spots of any kind. Individuals have four rows of papillae extending from the aboral organ in a figure eight pattern, also papillae along the margin (Fig. 1A); papillae appear glandular (Fig. 2) and are capable of extending or retracting so that they are indistinguishable from the aboral surface,

particularly with preserved specimens. With two tentacles, both with tentilla (Fig. 1A); oral groove present (Fig. 1B). Temporary chimneys may be formed by a bending upwards of the oral groove, with the tentacle emerging from the center of the chimney. Embryos present along the margins of some specimens, both preserved and live. Meridional canal structure has not yet been determined due to the opaque nature of the ctenophore body. Tentacular sheath morphology is highly variable ranging from anchor shaped (Fig. 1A) to ± shaped. This extra cross piece in the tentacle sheath is similar to that found in *Vallicula* Rankin, 1956, but the tentacles have not been observed coiled within the cross piece (as in *Vallicula*).

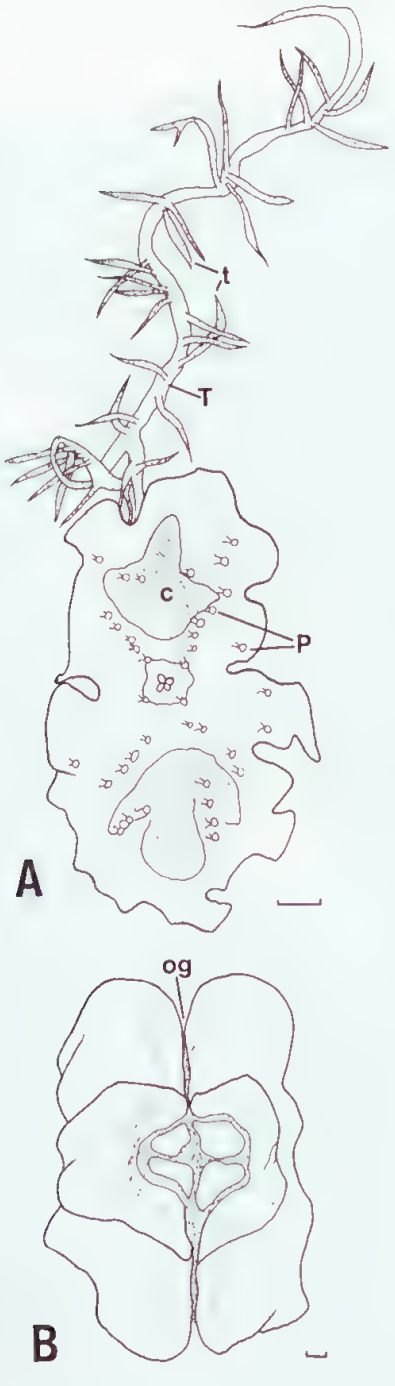

FIGURE 1. *Coeloplana scaberiae* sp. nov. Paratype SAM H844. Camera lucida sketches of aboral (**A**) and oral (**B**) surfaces. Note the presence of papillae (**P**) on the aboral side and the oral groove (**og**) on the oral side. The tentacles (**T**) have tentilla (**t**) that originate along one side of the tentacle. The tentacle sheath is large and has a cross bar (**c**) that can vary in shape and size. Scale bars = 1 mm.

Habitat

Found only on the brown alga *Scaberia agardhii* Greville, 1830, in colonies containing a single colour morph (red or orange) (Figs. 3, 4), usually on the tips of the plant. Very few *S. agardhii* are colonised, but when the ctenophores are present, they are abundant (from one to 50 per alga) and can be found on one or more branches, but rarely the whole plant. *C. scaberiae* is the first species of *Coeloplana* known to have an obligate association with a brown algal host.

Distribution

Central South Australia. Currently known only from the type localities, but has also been reported

FIGURE 2. *Coeloplana scaberiae* sp. nov. SEM of the aboral surface showing the aboral papillae (**P**) and rugose structure of the aboral surface. This is characteristic of preserved specimens; live specimens often have a smooth surface when fully extended. Scale bar = 400 µm.

from Victor Harbour, Encounter Bay, Fleurieu Peninsula, SA. Given the abundance of *Scaberia agardhii* in other areas of South Australia, further investigations should reveal the presence of *Coeloplana scaberiae* in these areas. *Scaberia agardhii* is endemic to southern Australia and it is likely that *C. scaberiae* is also endemic to this region.

Etymology

The species name *scaberiae* is derived from the generic name of its host alga *Scaberia*, in recognition of the specific association between the two species. Both names are based on the Latin *scaber* which is defined as rough, scabby, or mangy (Brown 1956), which describes both the ctenophore and its host alga.

FIGURE 3. *Coeloplana scaberiae* sp. nov. Paratypes SAM H846 (PH0141). In situ photograph showing ctenophores on the host alga *Scaberia agardhii*. There is a white sponge (s) that is always present and whose role in this commensal relationship is unknown. Scale bar = 0.5 cm.

FIGURE 4. *Coeloplana scaberiae* sp. nov. In situ photograph showing ctenophore (ct) with tentacles extended in a typical fishing posture, on the host alga *Scaberia agardhii*. Scale bar = 0.5 cm.

Behaviour

The ctenophores feed at night and can be induced to feed in the laboratory in darkness. This suggests that there is not a circadian type of rhythm influencing the feeding bouts. White light in the form of a flashlight, strobe, or room light quickly causes these animals to withdraw their feeding tentacles and cease feeding despite a high food abundance. The animals will feed and can be observed under red light, and have been kept in the laboratory for three weeks without any noticeable deterioration. The host alga *Scaberia agardhii* however tends to die after three weeks and the ctenophores have been difficult to transplant to another substrate. The ctenophores require a high flow rate and are very susceptible to infection from ciliates. Specimens in the laboratory were fed enriched *Artemia salina* nauplii and did well until the host plant died. This high specificity suggests that the association is a very restricted one. An unidentified white sponge has always been observed under the ctenophore and it is possible that the sponge is providing a food source or is the host rather than *Scaberia*.

The mode of reproduction in this species is not clear yet, but embryos have been found under the margin on 18 of 22 preserved specimens. Other species in this genus are thought to have brood pouches in the aboral papillae (Harbison & Madin 1982). Dissections of aboral papillae showed no signs of embryos or use of papillae as brood chambers. The papillae are hollow within and open directly into the gastrovascular cavity. Embryos are found under the ventral margin of preserved ctenophores, particularly within the folds of the margin. It is possible that the embryos are brooded within the papillae and are released through the oral opening when the ctenophores are stressed (i.e. placed into preservative). In addition to the brooded embryos, the ctenophores were observed to reproduce by fragmentation in the laboratory. This mode of asexual reproduction is unique to this order.

Discussion

The host specificity of most of the *Coeloplana* species and the bright and distinctive colouration are useful taxonomic characteristics. Some of the earlier descriptions are lacking in detail or in specimens (*C. metschnikowii* or *C. bannwarthi*), and the classification of the group may require revision when further material of these is discovered. A key is provided below for all of the known species in the genus. Descriptions are taken from the original literature except for *C. meteoris* (information from Arnold 1993).

Key To The Known Species Of *Coeloplana*.

1 – Host is an animal or plant 2
– Host unknown; or ctenophores found on sediment or in plankton 22

2 – Host is algae or seagrass 3
– Host is an animal 8

3 – Epiphytic on seagrass 4
– Epiphytic on algae 6

4 – Epiphytic on *Zostera* 5
– Epiphytic on *Posidonia*, ctenophore colour deep olive green with sepia spots, tentacles yellow brown with a narrow yellow orange margin .... *Coeloplana perrieri* Dawydoff, 1930

5 – Ctenophore colour grey (dorsal) and white (ventral) (colour possibly a fixation artefact) ..... *Coeloplana metschnikowii* Kowalevsky, 1880
– Host association not specific (originally described from "red *Zostera*" – possibly host plant was misidentified). Ctenophore colour deep purple, red or orange fading to pink with white spots along the margin and yellow blotches at the base of papillae .... *Coeloplana willeyi* Abbott, 1907

6 – Obligate epiphyte on the brown alga *Scaberia agardhii* .... *Coeloplana scaberiae* sp. nov.
– Epiphytic on algae other than *Scaberia agardhii* 7

7 – Epiphytic on red algae (e.g. *Melobesia* sp.) or brown algae (e.g. *Sargassum*), ctenophore colour brown to brownish yellow or chocolate brown with yellow white cells around the margin and two bands of yellow around the statocyst; 10–20 aboral papillae each with 2–5 digitate processes .... *Coeloplana mitsukurii* Abbott, 1902
– Host association not specific. Epiphytic on *Caulerpa*, red algae, coralline algae, *Sargassum*. Ctenophore colour deep purple, red or orange fading to pink with white spots along the margin and yellow blotches at the

base of papillae ..... *Coeloplana willeyi* Abbott, 1907

8 – Epizooic on echinoderm 9
– Epizooic on cnidarian 14

9 – Epizooic on echinoid 10
– Epizooic on asteroid 13

10 – Epizooic on *Diadema*, ctenophore colour solid dark purple matching host, known only from a fragmented specimen ..... *Coeloplana bannwarthi* Krumbach, 1933
– Epizooic on echinoid other than *Diadema*, ctenophore colour does not match host ... 11

11 – Epizooic on *Toxopneustes*, ctenophore colour yellow brown with a wide pale green margin ..... *Coeloplana echincola* Tanaka, 1931
– Epizooic on echinoid other than *Toxopneustes*, ctenophore colour not as above 12

12 – Epizooic on *Heterocentrotus mammillatus*, ctenophore colour brownish red, distinctive in lacking papillae ..... *Coeloplana weilli* Dawydoff, 1938a
– Host association not specific. Epizooic on *Heterocentrotus mammillatus*, *Echinothrix diadema*. Ctenophore colour deep purple, red or orange fading to pink with white spots along the margin and yellow blotches at the base of papillae ..... *Coeloplana willeyi* Abbott, 1907

13 – Epizooic on *Echinaster luzonicus* (Asteriidae), ctenophore colour mottled brownish red to brownish violet and white . .... *Coeloplana astericola* Mortenson, 1927
– Epizooic on *Pentaceros hedemanii* (Oreasteriidae), ctenophore colour unknown; 6–20 papillae ..... *Coeloplana krusadiensis* Devanesan & Varadarajan, 1942

14 – Epizooic on gorgonian or alcyonacean 15
– Epizooic on pennatulid *Pteroeides*, ctenophore colour intense orange or vermilion to orange; distinctive in lacking papillae ..... *Coeloplana duboscqui* Dawydoff, 1930

15 – Epizooic on gorgonian *Solenocaulon*, ctenophore colour brick red with white spots; oral groove present ..... *Coeloplana sophiae* Dawydoff, 1938b
– Epizooic on alcyonacean 16

16 – Epizooic on *Dendronephthys*, ctenophore colour dark vermilion, dark red, brick red, pink, orange, or grey stripes branching and anastomosing ..... *Coeloplana bocki* Komai, 1920
– Not epizooic on *Dendronephthys*..... 17

17 – Epizooic on *Cladiella* or *Alcyonium* 18
– Epizooic on *Sarcophyta* 20

18 – Epizooic on *Cladiella* or *Alcyonium*, ctenophore colour pink (in situ) or milky white (after preservation in formalin) with yellow tentacle bases and 4–5 pairs of papillae.....*Coeloplana komai* Utinomi, 1963
– Epizooic on *Alcyonium*, ctenophore colour and form not as above 19

19 – Ctenophore colour is milky white with brown spots; 14 papillae in two distinct rows ..... *Coeloplana gonoctena* Krempff, 1921
– Ctenophore colour clear, milky white, or violet brown; 6–16 papillae ..... *Coeloplana agniae* Dawydoff, 1930

20 – Ctenophore colour unknown; 40 papillae ... . *Coeloplana wuennenbergi* Fricke, 1970
– Ctenophore colour unknown; more than 40 papillae 21

21 – Ctenophore colour unknown; 70–100 papillae...*Coeloplana punctata* Fricke, 1970
– Ctenophore colour unknown; 60–70 papillae ..... *Coeloplana lineolata* Fricke, 1970

22 – Habitat known 23
– Host or habitat unknown, ctenophore colour unknown ..... *Coeloplana indica* Devansan & Varadarajan, 1942

23 – Ctenophore planktonic 24
– Ctenophore benthic in soft sediments; ctenophore colour clear with yellow white reticulations covering body and red pigmentation around canals, tentacle sheaths and papillae ..... *Coeloplana meteoris* Thiel, 1968

24 – Ctenophore colour is perfectly transparent pale green, with 7–8 aboral papillae, 32 orange papillae arranged in 8 rows ..... *Coeloplana mesnili* Dawydoff, 1938b

– Ctenophore colour transparent green; 8 papillae .... *Coeloplana tatersalli* Devansan & Varadarajan, 1942

From the above key and our observations, it is clear that the ctenophores discovered in South Australia are a distinct species. *C. scaberiae* is one of three *Coeloplana* species found on brown algae and it is the only obligate commensal species (*C willeyi* and *C. mitsukurii* can be found on *Sargassum*, but are also found on other substrates). *C. scaberiae* possesses an oral groove as does *C. sophiae* but lacks the white spots found on *C. sophiae* and *C. willeyi*. The presence of an oral groove and an extra cross piece in the tentacle sheath are diagnostic characters for the genus *Vallicula*. The presence of a permanent chimney formed from the oral groove is characteristic of the genus *Lyrocteis* Komai, 1941. *C. scaberiae* has an oral groove, can form temporary chimneys, and may exhibit the cross pieces in the tentacular sheath. These observations suggest that the designation of *Vallicula* and *Lyrocteis* in a separate family (Lyrocteidae) may need to be reconsidered. *C. scaberiae* is found with either red or orange colouration which is similar to the colouration of *C. willeyi*, but *C. willeyi* also has white spots along the margin and yellow spots at the base of the papillae that *C. scaberiae* lacks. Body colouration and host specificity clearly separate this new species from all of the described species. A molecular analysis of this group and the Phylum Ctenophora generally is in progress by one of the authors (GIM).

Acknowledgments

Thanks to Andrew Hogg, Keith Rowland, Helen Lulofs and Wolfgang Zeidler for their assistance with field collections. Katerina Kantalis transformed rough sketches into quality illustrations and Charles Galt and Susan Harris provided some essential references which were difficult to find in Australia.

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SUBFOSSIL EVIDENCE OF STRANDINGS OF THE SPERM WHALE *PHYSETER MACROCEPHALUS* IN GULF ST VINCENT, SOUTH AUSTRALIA

C. M. KEMPER, N. PLEDGE & J. K. LING

C. M. KEMPER, N. PLEDGE and J. K. LING. 1996. Subfossil evidence of strandings of the sperm whale *Physeter macrocephalus* in Gulf St Vincent, South Australia. *Records of the South Australian Museum* 29(1): 41–53.

Sperm whale *Physeter macrocephalus* bones and teeth found in Holocene sands along the eastern side of Gulf St Vincent have been studied and dated by comparative stratigraphy or carbon-dating of sediments in which they lay. Three skulls, two from just north of Parham and one from Port Gawler, were found 0.7 and 1.0 km inland from the modern coastline. They were in coastal sediments about 2000 years old. Other bones of *P. macrocephalus* found in various situations along Adelaide beaches could not be accurately dated because they were found in or on unstable sands. At least six animals were represented in the available material. Five (three males, two unsexed) were 8–12 m long and the other (a male) was about 14 m long. The specimens are the only records of sperm whales in Gulf St Vincent and may represent a two thousand year old mass stranding of bachelor males.

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Whale bones are occasionally uncovered from coastal sediments around Australia. Dixon (1990) reported on the skeletal remains of a southern right whale *Eubalaena australis* from Port Phillip Bay, Victoria. She suggested that the bones came from whales caught during nineteenth century whaling operations in the region. In South Australia many whale bones are found in the vicinity of nineteenth century whaling stations (Kostoglou & McCarthy 1991). The bones are usually identified as *E. australis* (C. Kemper, unpublished data), the principal species hunted from shore stations. The skeleton of a humpback whale *Megaptera novaeangliae*, probably deposited in the last few hundred years by a storm, was found buried on Moreton Island, Queensland (Bushing 1991).

The South Australian Museum holds several cetacean specimens of unknown age from Gulf St Vincent and Spencer Gulf. These include a blue whale *Balaenoptera musculus* part skull and skeleton recovered from sediments in mangroves near Whyalla and a part skull from shifting sand dunes near Cowell. Two bullae from a *M. novaeangliae* were donated by the Silicate Brick Company, Largs Bay and were presumably found in Holocene or Pleistocene deposits there. A partial rib of *E. australis* was found in shell grit at about 2 m depth while excavating for the foundations of the power station on Torrens Island, near Adelaide. Torrens Island sediments are believed to be less than 4000 years old (A. Belperio, pers. comm.). A lumbar vertebra, possibly of *E. australis*, was found in 2 m of sediments in the early Holocene Lipson Formation (Firman 1966), 1 km inland at West Lakes in suburban Adelaide.

Obtaining accurate carbon-dates for subfossil cetacean bones is difficult because all marine organisms are affected by the depletion of ^{14}C (relative to terrestrial wood, the standard for carbon-dating) in the marine environment. This is known as the 'reservoir effect' and it is greatest in the Antarctic and subAntarctic seas (Omoto 1983). Gordon & Harkness (1992) reviewed data for vertebrates and invertebrates in the Antarctic region and concluded that for whale bones a minimum correction factor of 1000 years may apply. For that reason, Bushing (1991) concluded that the geological age of the *M. novaeangliae* skeleton found on Morton Island, Queensland, dated at 1410 ± 70 years, was not subfossil. Radio-carbon dates for subfossil north Atlantic gray whales *Eschrichtius robustus* have been more informative (Bryant 1995) because the reservoir effect there is not as great, ranging from 365 to 750 years (Gordon & Harkness 1992), and because the subfossils that Bryant was studying were up to 8330 years old.

This study reports on three subfossil sperm whale *Physeter macrocephalus* skulls found in

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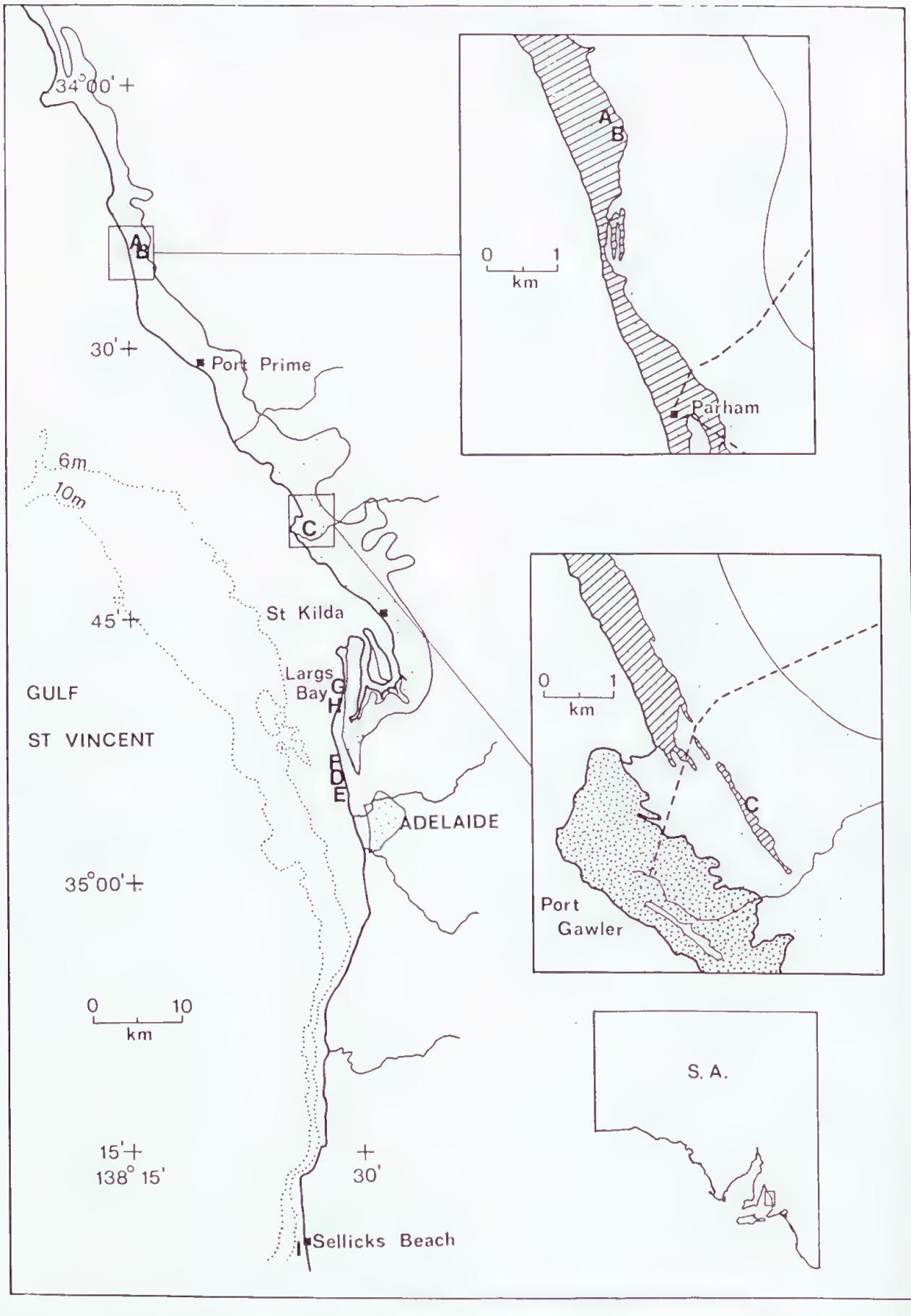

FIGURE 1. Location of sites where sperm whale skeletal material has been found along eastern side of Gulf St Vincent. ■ towns, - - - major roads, ⬚ mangroves, ⬚ Holocene sands, ▨ beach ridges, ····· water depth contours.

TABLE 1. Sperm whale skeletal material collected along the eastern coast of Gulf St Vincent, SA. Rel. = reliability of identification (see results). Reg. No. = P, Palaeontology, M, Mammalogy collections at the South Australian Museum. Date = date collected. GPO = general post office.

Spec.	Rel.	Material	Reg. No.	Date	Locality	Site
A	1	cranium, mandible, teeth, vertebra	P31428	1989	4 km N Parham	buried 1-2 m in shell grit, 700 m inland
B	1	part-cranium	–	1989	4 km N Parham	buried 1-2 m in shell grit, 700 m inland
C	1	cranium	–	1991	2 km NE Port Gawler	buried 1 m in shell grit, 1 km inland
D	2	caudal vertebra	M18064	<1960	Tennyson/North Grange	unknown
E	1	part-cranium, R mandible, caudal vertebra	M14434	1987	Tennyson, 10 km WNW Adelaide (GPO)	in sand, under 1.5 m water, well below low tide mark
F	3	part-cranium	M14435	1986	Tennyson, 12 km NW Adelaide (GPO)	on sandbar, after storm
G	1	part R mandible	M18059	1992	Largs Bay	foredunes?
H	1	L humerus	–	1993	Largs Bay	in seaweed, at high tide mark
I	3	2 parts cranium	M18061	1994	Sellicks Beach	found while dredging

FIGURE 2. Posterior end of the almost-complete skull of specimen A at Parham shown at the beginning of excavations. Note the coarse layer of shell grit, a storm deposit, in which the skull was lying. Photo: J. K. Ling.

TABLE 2. Skeletal measurements of known body length *P. macrocephalus* compared with those of the animals of unknown body length found in Holocene sands and discussed in this paper. Body lengths and sexes of specimens A-E, G and H are as estimated and discussed in 'Results'. L = length, W = width, H = height, D = depth, symph. = mandibular symphysis, Omura = Omura *et al.* (1962). Numbers refer to specimens in the Mammalogy (M) and Palaeontology (P) collections of the South Australian Museum.

			Teeth		Mandible			Skull		
No.	Sex	Body Length (m)	Pulp Cavity	Max. Size (mm)	Total Length (m)	Symph. Length (m)	Alveoli (L,W,D) (mm)	Greatest Length (m)	Greatest Width (m)	Other (mm)
M15007	M	8.0	very open	45	1.6	0.7	20, 40, 25	1.9	1.1	
M16613	F	10.2	most occluded	105			55, 28, 35	2.5	1.1	depth of symph.= 110
M7194	M	11.3						2.3	1.4	
M16612	F	12.2	most occluded	110	~2.2	~1.0	60, 30, 45			depth of symph.= 90-100 humerus=300
M9544	M	12.8	quite open	135						
M14442	M	13.5	well open	180			120, 60, 60			depth of symph.= 90-110
Omura	M	14	well open	102	3.0	1.7		3.6	1.7	11th caudal H=260, W=230, humerus L=400
M5585	M	16	some occluded	205	5.1			6.1	2.6	11th caudal H=300 W=300 symph.=240
P31428 (A)	M	~12	very open	95	~2.4			~2.5		
B	?	~11						~2.1	>0.8	
C	?	~8						~1.7	~1.0	
M18064 (D)	M	~14								centrum H=260, W=230
M14434 (E)	M	12-13			~2.5	~1.3	70, 50, 55			depth of symph.= 90–110
M18059 (G)	M	~12					85, 40, 50			depth of symph.= 120
H	M	12-13								humerus L=330

FIGURE 3. Lateral view of specimen B at Parham after excavations were complete. Photo: N. Pledge.

Holocene sediments north of Adelaide and compares them with other *P. macrocephalus* bones found on the eastern shores of Gulf St Vincent.

Materials And Methods

In 1989 Australian Consolidated Industries (ACI) discovered two large skulls in their shell grit mines near Parham, 70 km north of Adelaide. In 1990 another skull was reported in a smaller pit at Port Gawler, 40 km southeast of Parham. Over the last 50 years whale bones have also been found along Adelaide beaches and donated to the South Australian Museum (SAM).

The specimens studied were collected from various situations and locations (Table 1, Fig.1). Specimens A, B and C were found in pits being excavated for shell grit; A and B from the ACI pit north of Parham where, according to ACI personnel, other bone fragments have appeared during digging operations, and C was from a pit used by the owners of the property "Buckland Park". Some donated specimens (F, I) were picked up along Adelaide beaches after becoming exposed by storms. One set of bones (E) was found while the collector was snorkelling. Specimen I was found while dredging sand.

Most of the skeletal material is registered in the Palaeontology and Mammalogy collections of SAM but because the skulls found near Port Gawler (specimen C) and Parham (A, B) were too fragile to move, they were studied and photographed *in situ*. The more robust mandible and teeth which lay beneath the skull of specimen A were collected and treated with bedacryl, a consolidant and hardener. The vertebra associated with specimen A was collected from near the skull by ACI personnel. Specimen I was studied and photographed by the SAM but is held privately.

Skulls of specimens A, B and C were measured from scaled photographs taken with a 35 mm camera.

Sex was determined from tooth, mandibular, alveolar and vertebral size and/or development when compared with skeletons of recently stranded *P. macrocephalus* held at SAM or described in the literature.

FIGURE 4. Posterior view of specimen C at Port Gawler after excavations were complete. Photo: L. Queale.

Results

Identity

The bones and teeth were identified as *P. macrocephalus* after comparison with reference specimens held at SAM and descriptions in Flower (1869). Their identification reliabilities (ID) were rated as follows: 1 = certain, 2 = probable, 3 = uncertain (Table 1). Table 2 lists the measurements obtained from the specimens.

In all three almost-complete skulls (A,B,C; all ID = 3) the tall supraoccipital and maxillary crest was missing (Fig. 2, 3, 4). The shape of the dorsal surface of the rostrum was consistent with *P. macrocephalus*. The condition of specimen B had deteriorated badly by the time its study began and its features were not as clear as in the other skulls. However, the distinctive shape of the rostrum and exoccipitals (Fig. 3) made the identification as *P. macrocephalus* certain. Associated with specimen A were 23 well-preserved teeth, a distinctively-shaped mandible (alveoli eroded away), bullae and periotics. All compared well with recent *P. macrocephalus* (Fig. 5, 6).

Cetacean caudal vertebrae are difficult to identify because many of the features used for distinguishing species are much reduced in this part of the vertebral column. Specimen D (Fig.7), a caudal vertebra (ID = 2), was oval when viewed anteriorly and it had a simple, reduced neural spine. It was very similar to the 11th caudal vertebra of a large *P. macrocephalus* (SAM M5585) and the description of the same vertebra in Flower (1869). In contrast, the caudal vertebra of a *B. musculus* at SAM was almost round and the neural spine was bipartite anteriorly. No comparative material of *E. australis* was available so we could not be certain that it was not this species.

Specimen E (Fig.8) consisted of an almost complete mandible with 19 large alveoli, one caudal vertebra and two parts of the cranium (possibly portions of the maxilla and occipital). All were clearly *P. macrocephalus* (ID = 1).

Specimen F (Fig. 9) was possibly part of the exoccipital or squamosal region of a medium to large whale. It did not seem to be part of *Balaenoptera* spp., *M. novaeangliae* or *E. australis*. However, its identification here as *P. macrocephalus* is uncertain (ID = 3).

The part right mandible (G) had six large alveoli (Fig. 10) and was probably from the mid section of the lower jaw. It was clearly *P. macrocephalus* (ID = 1).

Specimen H (Fig. 11) was a humerus which compared well (ID = 1) with the sperm whale features described by Flower (1869), including the long tubercle on the radial border connecting with the tuberosity.

Specimen I (Fig. 12) consisted of two parts of the skull, possibly incomplete frontals, of a large cetacean. The identification assigned to *P. macrocephalus* is uncertain (ID = 3).

Size, sex and number of animals

Adult male and female *P. macrocephalus* are very dimorphic in size, males growing to 18.3 m and females to only 12.5 m (Rice 1989). There is also a distinct difference in the size of the teeth (Rice 1989), making it possible to distinguish the sexes at all ages. Sufficient reference material of different sexes and relative ages is held at SAM, supplemented by published measurements

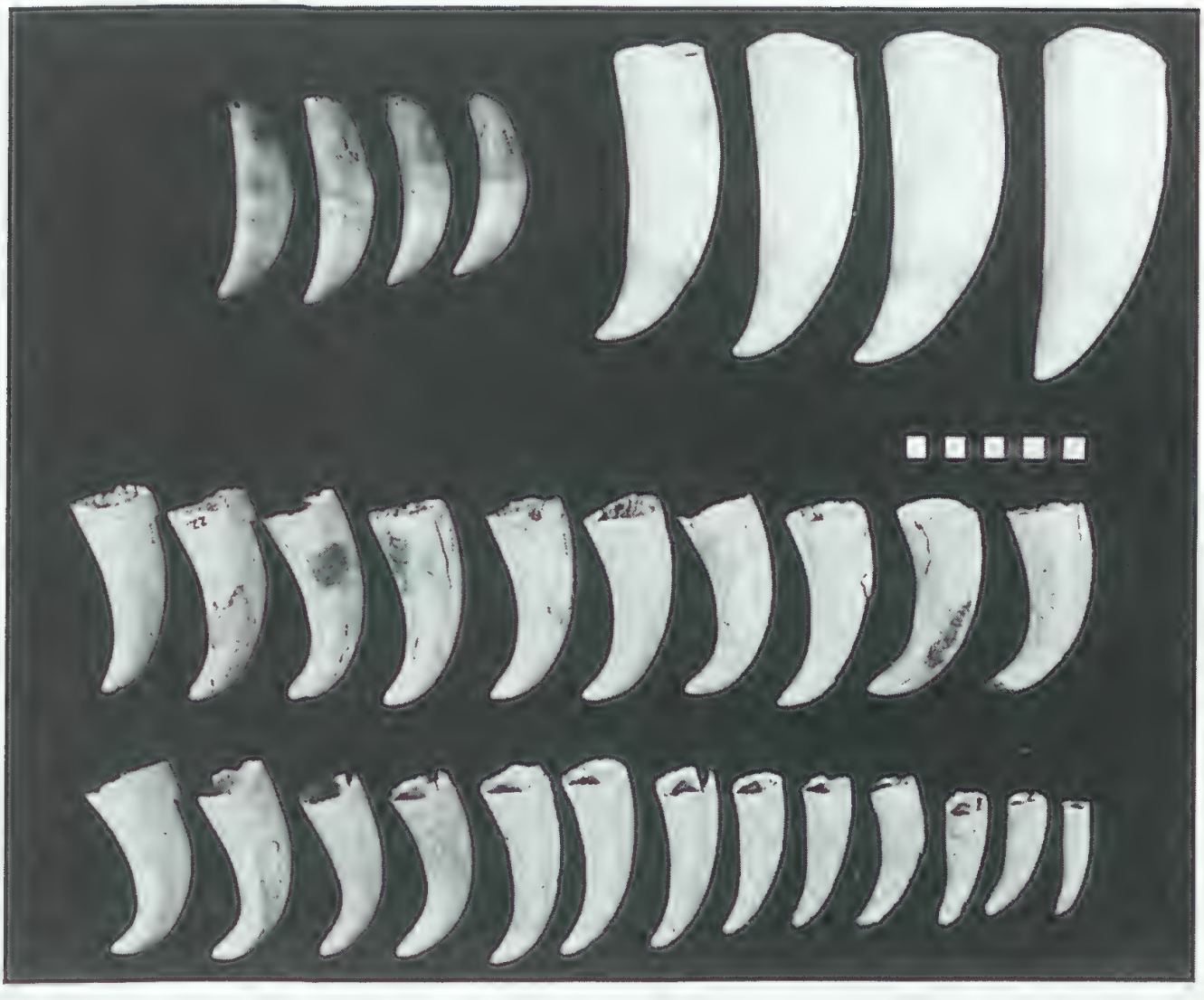

FIGURE 5. Teeth of Parham specimen A (top two rows) compared with recently stranded specimens in the Museum's collection. Four large teeth on bottom left are from the mid-mandible of a 13.5 m male (SAM M14442). Four smaller teeth on lower right are from the mid-mandible of a 10.2 m female (SAM M16613). Scale bar is in cm.

(Omura *et al.* 1962), to compare with the specimens from the present study and make some conclusions regarding their size and sex (Table 2).

The teeth of specimen A were open-rooted (Fig. 5), as would be the case in a young animal, yet they were only slightly smaller than the teeth of adult females (SAM M16612, SAM M16613) with almost occluded dental cavities. The length of the mandible was about the same as that of a 12.2 m female (SAM M16612). Specimen A was therefore from a subadult male, about 12 m long. Specimen B was a very damaged skull, about 2.1 m long. By its size it could have been from a female or a young male. Specimen C was a skull of about the same length as that of an 8.0 m male *P. macrocephalus* (SAM M15007). Without teeth or a mandible it was not possible to say whether it was from a female or male.

The remaining specimens were more incomplete but it was still possible to estimate their sex and/or length in most cases. The large caudal vertebra (specimen D) was the same size as the 11th caudal vertebra of the 14 m male described by Omura *et al.* (1962). It appeared to lack fused epiphyses although this was difficult to determine because the surfaces were very worn. For specimen E, the length of the almost-complete mandible, size of the mandibular alveoli and depth of the mandibular symphysis were all greater than for a 12.2 m female (SAM M16612). These comparisons suggest that it was from a male, about 12–13 m body length. Specimen G, a part right mandible, could not have been the same animal as E, also a right mandible. The depth of the symphysis and the size of the alveoli, at least

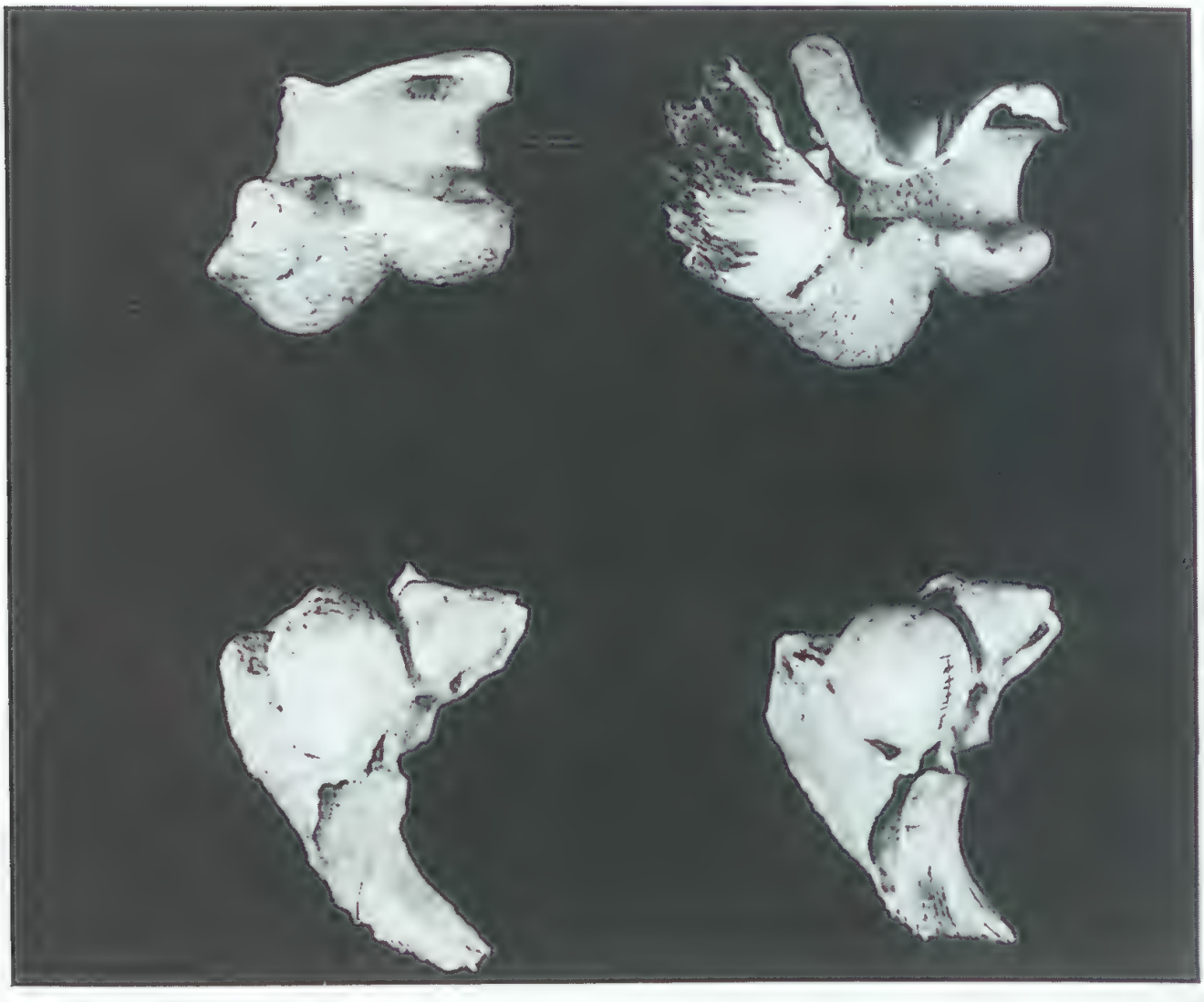

FIGURE 6. Bulla (top left) and periotic (bottom left) of Parham specimen A compared with the same (right) of a recently stranded *P. macrocephalus* (SAM M14441) of unknown length and sex. Left periotic is 62 mm maximum length.

as represented in this piece, were both less than in a 13.5 m male (SAM M14442) which suggests that it was from an animal about 12 m long. The humerus (specimen H) was slightly longer than that of an adult female (SAM M16612) and its proximal epiphysis was not fully fused. It was probably from a 12–13 m male. No size or sex was assigned to specimens F and I.

At least six individual *P. macrocephalus* were represented in the material available (Table 2). The skulls of A, B and C were three individuals. Specimens E and H could have been from the same animal, which was different from G. Specimen D was from an animal larger than those described above. The total number of each sex/size category therefore represents three subadult males (about 12–13 m long), one adult male (about 14 m) and two unsexed animals about 8 and 11 m.

Geological Age

It was not possible to assign a geological age to all specimens. The three skulls (A,B,C) found in shell grit pits at Parham and Port Gawler all lay at approximately the same depth (1–2 m) below the surface of the ground and were deposited in a deep layer of coarse shell grit, a storm deposit, overlaid with finer material (Fig. 2). The coarse shell grit in which specimen C was found has been radio-carbon dated at 2020± 90 years BP, taking into account the reservoir effect (A. Belperio, pers. comm.). The age of the storm deposit layer in the ACI bed has been estimated at approximately 2000 years BP (A. Belperio, pers. comm.). Specimens A and B were located 700 m from the present-day shore of Gulf St Vincent and about 200 m from each other. Specimen C was 1 km inland (i.e. from the

FIGURE 7. Caudal vertebra (specimen D) from Tennyson/North Grange showing weathered anterior surface of centrum with epiphysis missing. Scale bar is in cm.

landward edge of the mangroves).

The remaining bones were found in various situations at, or very near, the present shoreline. Most were found on the beach but one (E) was found well below low water mark and partially buried in the sand under 1.5 m of water and another was uncovered while dredging sand. It was not possible to estimate the accurate geological age of any of these specimens because the sands in or on which they were found were not stable and therefore not conducive to comparative stratigraphy. The sediments were, however, Holocene in origin and therefore less than 10 000 years BP.

Discussion

The skulls found in Holocene sediments near Parham and Port Gawler were dated at about 2000 years BP, judging by the age of the shell grit in which they lay. Radio-carbon dating of the bones themselves seemed inappropriate because of the 1000 year correction factor suggested by Gordon and Harkness (1993) to adjust for the 'reservoir effect'. The reservoir effect increases from lower to higher latitudes in the Southern Hemisphere but *P. macrocephalus* ranges over a wide latitudinal area. Adult males venture further south, as far as 70° S (Leatherwood and Reeves 1983), than females and juvenile males which rarely go further than 45° S. Since the animals described in this study were not adult males and therefore would not have travelled very far south, the reservoir effect correction factor would probably be less than 1000 years had their bones been carbon-dated. Radio-carbon dates for recently stranded *P. macrocephalus* along the Australian coast are needed to confirm this hypothesis.

The skulls were well inland (700 and 1000 m) from the present-day coast and record a time when the coast was inland of its present position. The fact that one of the Parham skulls was found with its mandible and teeth still adjacent to it suggests that it was an intact specimen, not a beached washed skull, when it was deposited. South of Parham, shells within the beach ridges of the St Kilda Formation have been radio-carbon dated. At 1 km inland, their estimated age is 3010 ± 80 years BP and just behind the seaward ridge (*ca* 300 m inland) the estimated date is 1820 ± 50 years BP (A. Belperio, pers. comm.).

It is possible that the animals stranded at the same time, although this would be impossible to prove even with accurate dating of the specimens. The two Parham skulls lay at the same depth and within 200 m of each other. The Port Gawler skull was in the same sediment layer about 40 km south of the Parham skulls. Since writing this paper, another *P. macrocephalus* mandible has been found at the Parham site but the mining machinery accidentally smashed it before it could be studied. There are no records of mass strandings of *P. macrocephalus* in South Australia (Kemper & Ling 1991) but several have been recorded in Tasmania (Nicol & Croome 1988). The eastern shores of Gulf St Vincent have been the site of two mass strandings of other species: five short-finned pilot whales, *Globicephala macrorhychus*, at St Kilda in 1903; and about 250 false killer whales, *Pseudorca crassidens*, along the coast between Parham and Port Gawler in 1944 (Hale 1945). In Gulf St Vincent most of the cetacean strandings occur along the eastern side, possibly as a result of the prevailing southwesterly winds (Kemper & Ling 1991).

The estimated body lengths of the animals

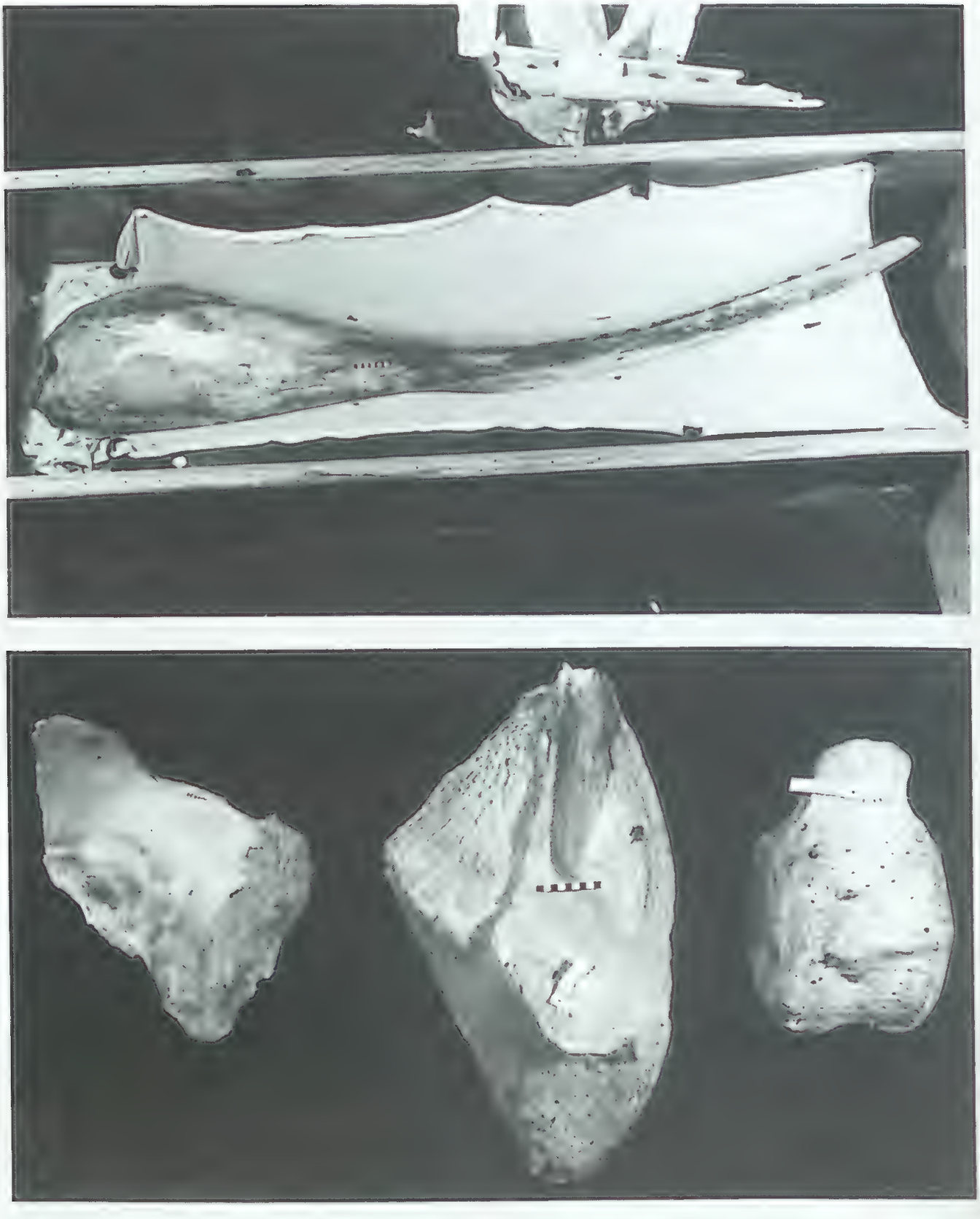

FIGURE 8. Upper photograph: Specimen G (being held) and mandible of specimen E. Lower photograph: two cranial pieces (possibly parts of the occipital and maxilla) and caudal vertebra of specimen E.

studied here were 8–14 m. Three of the six animals were clearly subadult males, about 12–13 m long. Two were a little smaller (8 and11 m) and may have been either male or female. If a mass stranding of *P. macrocephalus* did occur, it may have been a school of bachelor males. Such associations are well known and include males generally less than 12 m body length (Rice 1989).

FIGURE 9. Specimen F, a part-cranium (possibly part of the exoccipital or squamosal region), from Tennyson. Scale bar is in cm.

Schools of both bachelor males and breeding females are known to mass strand, and at about the same frequency (Rice 1989).

Holocene coastal marine sediments are extensive in South Australia (Belperio *et al.* 1983) and may be the source of many cetacean bones, some of which could be subfossil. These sediments have been deposited during the last 10 000 years. They are especially abundant on the eastern side of Gulf St Vincent where there is a series of inland beach ridges representing old shorelines (Belperio *et al.* 1983). The unconsolidated shell beds, and samphire and tidal flat deposits are called the St Kilda Formation (Firman 1966). It is 2–3 m thick and lies above the Pleistocene Glanville Formation, a cemented, shelly limestone. Layers of coarse shells, probably storm deposits, occur in the St Kilda Formation.

The *P. macrocephalus* specimens found along Adelaide beaches were highly unlikely to have been from whaling because this species inhabits the deep ocean. The waters of Gulf St Vincent are very shallow (less than 50 m). and the continental slope is 250 km south of Port Gawler. The two whaling stations recorded in Gulf St Vincent, one at Port Noarlunga, just south of Adelaide, and one at Cape Jervis, about 100 km south of Adelaide (Kostoglou & McCarthy 1991), would not have taken sperm whales.

Without radio-carbon dating the specimens which were found along beaches the possibility exists that they were from strandings in the last few hundred years and not subfossil. However, a thorough search of whale stranding records held at SAM and a public appeal in 1987 to find out if any sperm whales had ever been recorded as stranding along the Adelaide coast failed to find any evidence of such an event in the last 110 or so years (Kemper & Ling 1991). A dead animal the size of *P. macrocephalus* would certainly have been noticed in a populated area such as Adelaide. *P. macrocephalus* strandings have been recorded on the north coast of Kangaroo Island, near the entrance to Gulf St Vincent and over 100 km southwest of Adelaide (Kemper and Ling 1991). There have been no reported sightings of live sperm whales in Gulf St Vincent (SAM records).

FIGURE 10. Specimen G, a partial right mandible, from Largs Bay, showing distinct alveoli typical of *P. macrocephalus*. Scale bar is in cm.

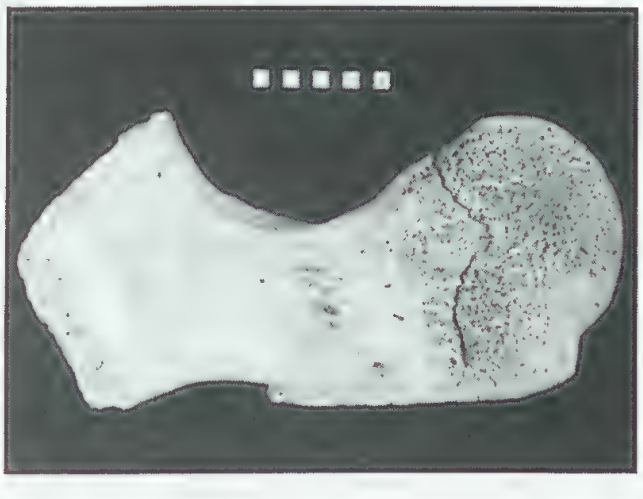

FIGURE 11. Specimen H, a left humerus, from Largs Bay. Scale bar is in cm.

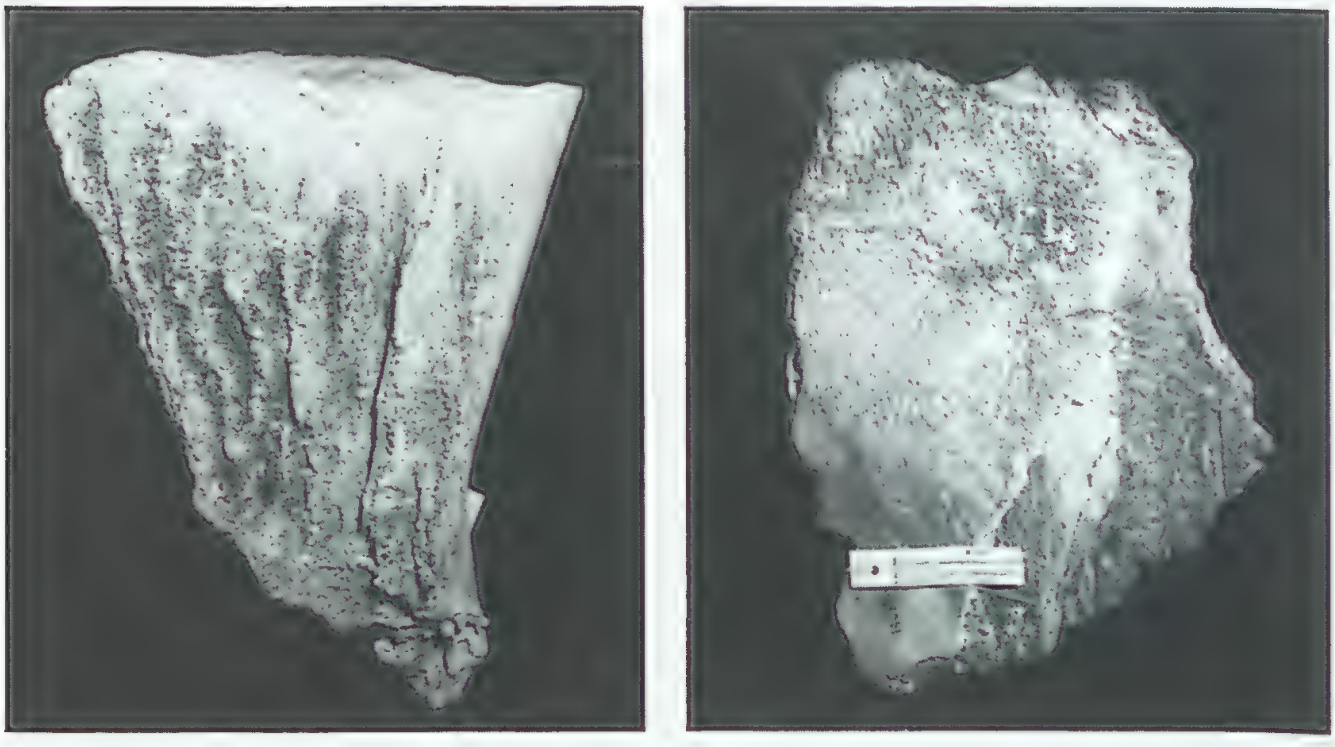

FIGURE 12. Specimen I, two part-crania (possibly part of the frontal region), from Sellicks Beach. The label is 10 cm long.

ACKNOWLEDGMENTS

We would like to thank Australian Consolidated Industries and their staff, Trevor Gilbert, Trent Baker and David Flew, for alerting us to the whale skulls at their shell grit pit near Parham. They also generously gave us logistic support during the excavation. We are also grateful to the owners of Buckland Park for allowing us access to the shell grit pit and to Lyn Pedler for making us aware that the skull was there. The help of all those who assisted with the excavations, especially Ben McHenry, Jim McNamara, Lynette Queale, Tim Verscoyle, Jenni Thurmer, Lyn and Janet Pedler, and members of the Mammal Club of the Field Naturalists Society of SA, is appreciated. We thank Jim McNamara for consolidating the teeth and mandible of specimen A. Tony Belperio made available the ages of the Holocene deposits and commented on the results of our study. Graham Carpenter made many useful suggestions on the manuscript. Thanks go to the people who donated the specimens discussed in this paper. Gillian Taylor provided references on the reservoir effect and Trevor Peters took the photographs.

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DESCRIPTION OF A NEW AUSTRALIAN MITE (ACARINA: TROMBIDIOIDEA), WITH COMMENTS ON SUPERFAMILY CLASSIFICATION

R. V. SOUTHCOTT

SOUTHCOTT, R. V. 1996. Description of a new Australian mite (Acarina: Trombidioidea), with comments on superfamily classification. *Records of the South Australian Museum* **29**(1): 55–62.

A new larval mite, *Yurebilla gracilis* gen. et. sp. nov., is described from the Mount Lofty Ranges, South Australia, from among soil and leaf litter, free-living. A new family, Yurebillidae fam. nov. is proposed for it. The classification of the superfamily Trombidioidea and related groups is discussed.

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The superfamily Trombidioidea is a large, cosmopolitan, diverse group of Acarina. Various attempts to classify its members into family, and higher and lower, groupings have been made over many years, since the pioneer studies of Berlese (1910, 1912). All students of the Trombidioidea (and other Parasitengona) have had to face the fact that extreme heteromorphy exists between the larval and postlarval instars, so that in many cases, following the small numbers of correlations that have been achieved between the larvae and the postlarvals, a dual generic and specific nomenclature has evolved (see e.g. Southcott 1994). Subsequently, revision of the classification of the Trombidioidea were made by Oudemans (1923), Thor (1935a, b), Thor & Willmann (1947), Feider (1959, 1979), Vercammen-Grandjean (1973), Robaux (1974), Southcott (1982, 1987a,b) and Welbourn (1984, 1991). Welbourn (1984) estimated that the Trombidioidea contained 'some 225 genera, and more than 3000 species', and contained 'an unsettled number of families'.

He divided the superfamily into eight tribes, using a total of 41 larval characters, largely based on chaetotaxy; characters of the adults were not used. In his second cladistic revision (1991) he followed Feider in elevating the previous group Trombidioidea to a 'subcohort Trombidiina' (Feider had used the term 'phalanx'), which he divided into four superfamilies, using a total of 19 larval characters and six adult characters.

In the present paper is described a new trombidioid larva, obtained by systematic Berlese funnel extractions of samples of soil and litter from the Mount Lofty Ranges, South Australia. As the characters of this larva do not fit into any of the existing classifications of the Trombidioidea including the most recent ones of Welbourn (1984, 1991), a new family, genus and species is proposed. The classification of the Trombidioidea will be discussed.

Materials And Methods

The mites were collected as larvae by systemic Berlese funnel extractions from soil and litter samples taken in the Mount Lofty Ranges, South Australia. All were collected free-living; none was attached to an arthropod host. Initial extracts were made into 70% ethanol, later specimens were collected live in the hope of making significant biological observations.

Students of the higher classification of the Trombidioidea have used the suprageneric terms with various expanded or restricted definitions, with varying status. Thus one finds the term referring to the trombiculid mites used as Trombiculini, Trombiculinae, Trombiculidae and Trombiculoidea, with varying content, similarly with Chyzeriini, Chyzeriinae, Chyzeriidae and Chyzerioidea, and the same applies with other trombidioids. In order to save redefining each term as it is discussed, as far as possible family terms will be used, with -idae endings, without a formal commitment to the ultimate status of the taxon.

All drawings were made using an Ortholux/ Laborlux microscope, with a drawing apparatus. All measurements are in micrometres (μm) unless otherwise stated.

Setal and other coding follows Southcott (1992,

1993, 1994). The holotype and paratypes are deposited in the South Australian Museum (SAM).

Systematics

YUREBILLIDAE new family

Diagnosis of larva

Trombidioidea. Eyes two on each side, sessile. Prodorsal scutum with anterior nasus, six non-sensillary setae and two sensillary setae. Scutellum absent. Palpal and pedal supracoxalae absent. Gnathosoma without chitinous mouth-ring. Coxalae I & II contiguous, with urstigma on posterior part of coxa I. Coxal setal formula 2, 1, 1: medial coxala I and coxalae II & III nude. Leg segmental formula 6, 6, 6. Leg tarsi with 3, 3, 2 claws (i.e. posterior claw of tarsus III absent). Leg tarsi without ventral sensalae (eupathidalae). Palpal femur and genu without setae.

Postlarval stages not known.

Type genus *Yurebilla* gen. nov.

Remarks

Yurebillidae resembles the family Allothrombiidae, but differs by having a nude medial coxala I and in lacking a scutellum, and in having a coxal setal pattern of 2, 1, 1 instead of 2, 2, 1.

The family at present contains only the genus with its type species *Y. gracilis* sp. nov.

Yurebilla gen. nov.

Diagnosis of larva

With the characters of Yurebillidae, and : odontus (palpal tibial claw) bifid. Trochanteralae 1, 1, 1. Femoralae 5, 4, 4. Genualae 6 (4Sc +1So +1Vs), 5 (3Sc + 1So + 1Vs), 4 (3Sc + 1So).

Type species *Yurebilla gracilis* sp. nov.

Etymology

The term *Yurebilla* is derived from the aboriginal (Kaurna) name for Mount Lofty, South Australia (Ellis 1976).

Yurebilla gracilis sp. nov.

(Figs 1A–C, 2A–C)

Material examined

Holotype: South Australia, Mount Lofty (summit), in soil and leaf litter in *Eucalyptus obliqua* forest, (sample TX272), 4.i.1988, R. V. Southcott, extracted by Berlese funnel 9.i.1988, larva (SAM ACA985).

Paratypes: South Australia. Mount Lofty summit, site as for holotype, sample TX280, 5.iv.1988, larva ACB1019, RVS, extracted by Berlese funnel 12.iv.1988. Same site, sample TX297, 18.i.1990, five larvae ACB1121, 1122A–D, RVS, extracted 20.i.1990; one larva ACA1123, extracted 21.i.1990, RVS. Waitpinga Beach, southern Mount Lofty Ranges, 17.xi.1953, RVS, sample TX60, one larva ACB606, extracted into ethanol. All in SAM.

Description of larva

The following description is based on the slide-mounted holotype, supplemented by paratypes. Metric data for the holotype and paratypes are given in Table 1.

Colour in life orange. Idiosoma 625 long, 295 wide; total length to tip of chelicerae 655 (the same idiosomal and total measurements before mounting were 584, 249, 627 respectively). Dorsal scutum oblong, with undulate borders; anterior end produced into a blunt-pointed nasus; scutum weakly chitinized, without special markings. Scutalae pointed, nude; AM setae near root of nasus; AL setae small, arising slightly anterolateral to sensillary setae bases; PL setae arise near posterolateral angles of scutum. Sensillary setae slender, tapering, with fine setules in distal half. Dorsal scutum with a central longitudinal rod (crista), 30 long, from behind level of AM setae to about 6 posterior to level of sensillary setae bases. Eyes: each lateral eye pair lateral to posterior half of scutum; eyes circular, anterior 9 across, posterior 6 across.

Dorsum of idiosoma with 20 setae, arranged 2, 4 ,6 2, 4, 2; first pair about one-quarter back from anterior end of dorsum (hence no 'ocular' setae are present). Setae slender, mostly almost spiniform (a few faint setules present); the most posterior pair with a few adnate, slight setules as is the case with the most posterior ventral pair. All idiosomal setae arise from a small basal plate.

Ventral surface of idiosoma with a pair of almost spiniform setae, 18 long, arising well behind coxae II. Behind coxae III are three pairs of similar setae, 18–24 long, followed by the posterior pair, 40 long. Lateral coxala I at the anterolateral angle of the coxa, with three or four setules; medial coxala I and coxalae II and III slender, spiniform. Anus apparently imperforate.

Legs: lengths I 240, II 185, III 210 (including

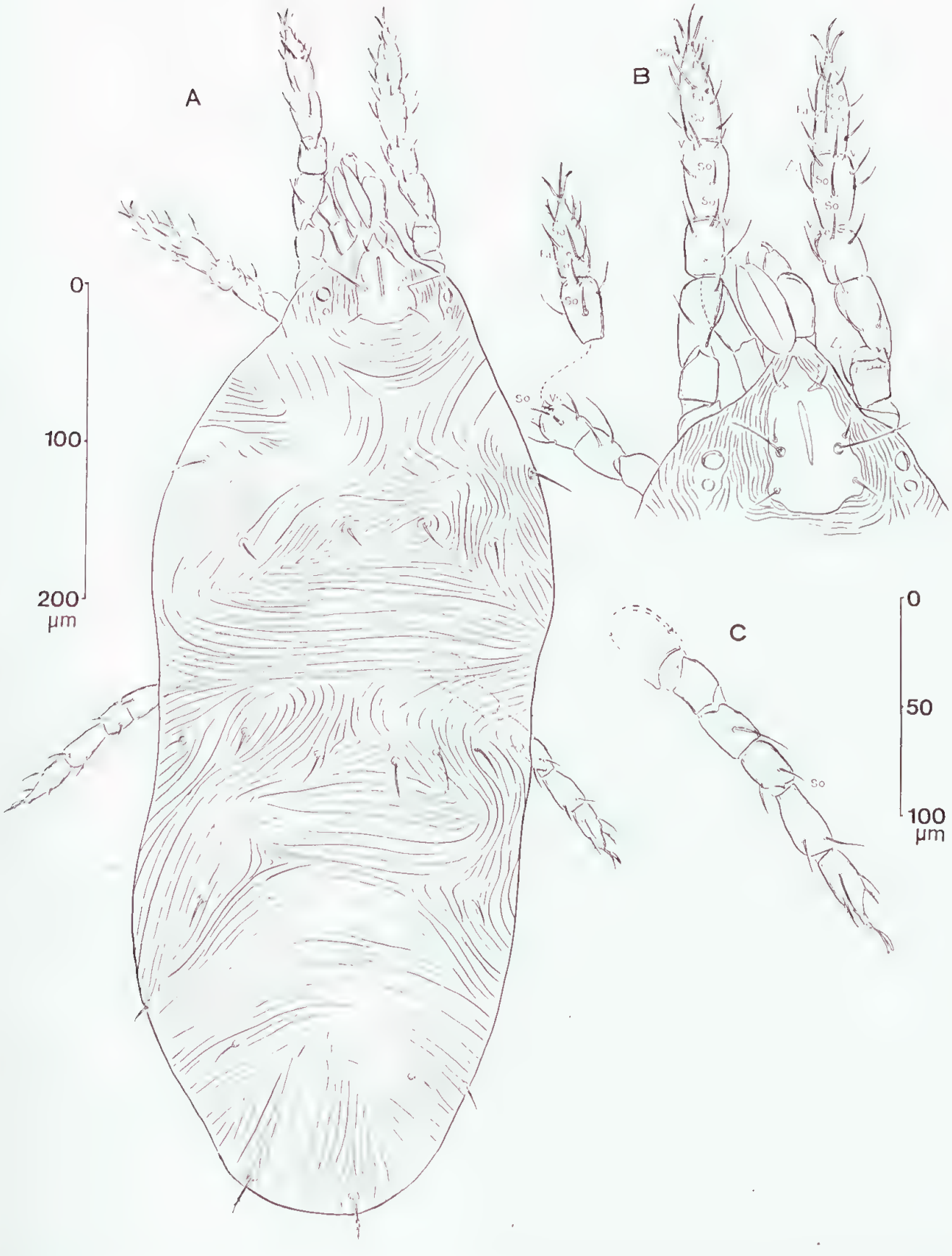

FIGURE 1. *Yurebilla gracilis*, gen. et sp. nov., larva, holotype. **A**, Dorsal view, entire. **B**, Propodosoma and adjacent structures, dorsal view. **C**, Leg III, dorsal view. (Figures to standard symbols; each to nearer scale.)

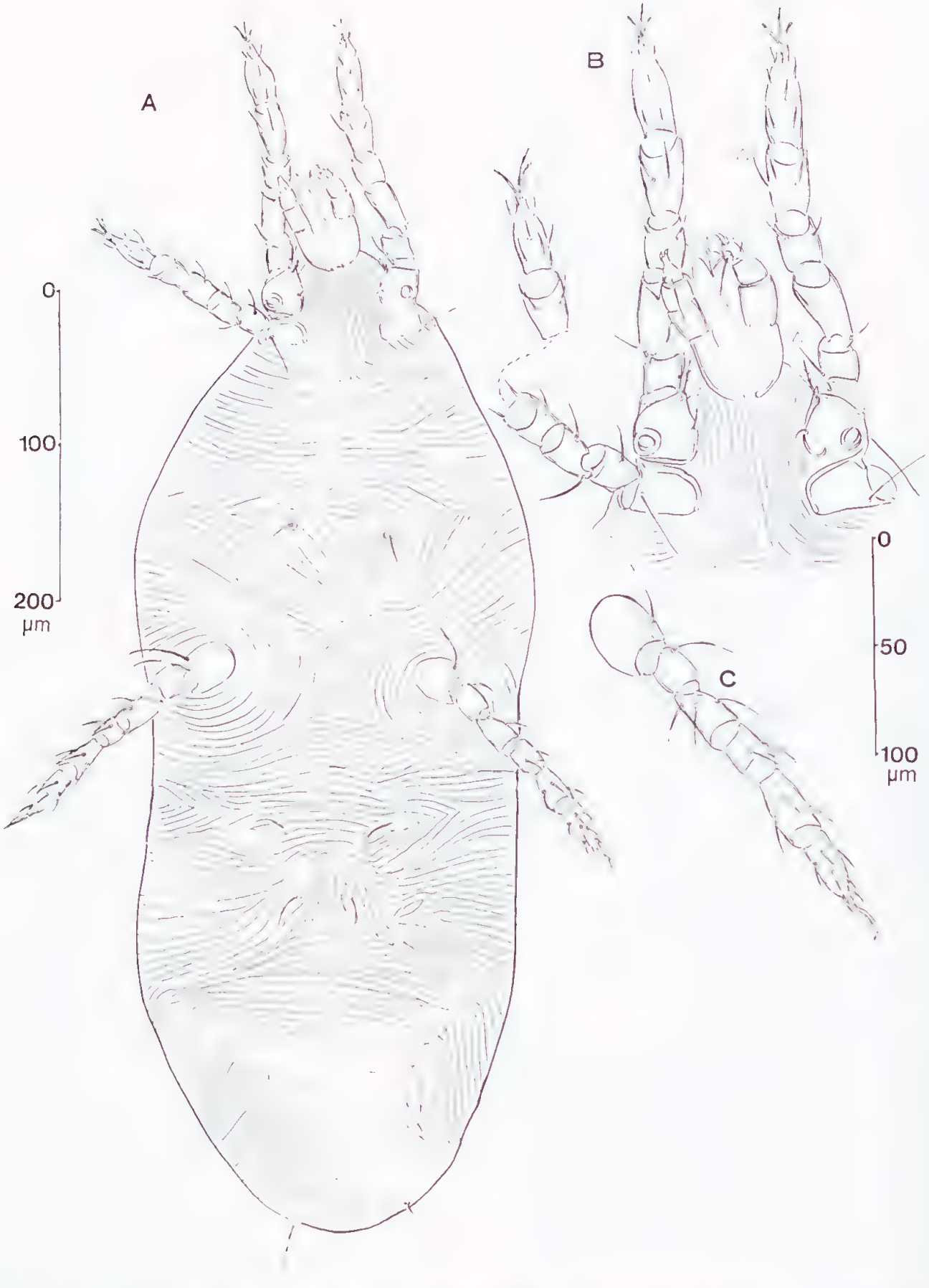

FIGURE 2. *Yurebilla gracilis*, gen. et sp. nov., larva, holotype. **A**, Ventral view, entire. **B**, Propodosoma and adjacent structures, ventral view; symbols standard. **C**, Leg III, ventral view. (Each to nearer scale.)

TABLE 1. Metric data for *Yurebilla gracilis* gen. et. sp. nov., larva

Character	Holotype	n	range	mean	s.d.	c.v.
LN	c. 15	9	10-23	17.7	3.97	22.5
MA	32	9	27-32	30.4	1.51	5.0
AW	29	9	29-37	33.7	2.45	7.3
PW	32	9	32-38	34.9	2.26	6.5
SB	22	9	22-30	26.3	2.24	8.5
MSA	29	9	25-31	28.7	1.73	6.0
ASB	54	9	43-58	52.6	4.30	8.2
PSB	32	9	29-36	32.8	2.39	7.3
L	86	9	77-92	85.2	5.02	5.9
W	40	9	40-57	49.7	5.20	10.5
AP	23	9	20-27	23.7	2.45	10.3
SA	7	9	7-9	7.44	0.726	9.8
SP	18	9	16-21	18.7	1.50	8.0
AM	19	9	13-20	17.9	2.32	12.9
AL	13	9	10-15	12.6	1.33	10.6
PL	18	9	18-23	21.6	1.42	6.6
AMB	19	9	18-23	19.6	1.59	8.1
SE	53	9	49-59	54.2	2.68	4.9
DS	24-33	9	33-40*	36.2*	2.05*	5.7*
MDS	22	9	22-25*	22.9*	0.928*	4.1*
PDS	33	9	33-40*	36.2*	2.05*	5.7*
FeI	37	9	33-46	41.2	4.52	11.0
GeI	28	9	22-29	25.6	2.35	9.2
TiI	38	9	35-43	37.3	2.65	7.1
TaI(L)	41	9	38-45	42.3	2.00	4.7
TaI(H)	22	9	17-23	19.6	2.01	10.3
TiI/GeI	1.36	9	1.28-1.64	1.46	0.104	7.1
FeII	27	8	27-34	31.1	2.23	7.2
GeII	19	9	18-22	20.8	1.48	7.1
TiII	23	9	23-33	28.4	3.32	11.7
TaII(L)	42	9	29-42	36.6	3.97	10.9
TaII(I)	16	9	16-19	16.4	1.01	6.2
TiII/GeII	1.21	9	1.19-1.61	1.36	0.140	10.3
FeIII	38	9	33-40	36.3	2.65	7.3
GeIII	22	9	19-24	21.8	1.79	8.2
TiIII	39	9	28-40	35.1	3.66	10.4
TaIII(L)	33	9	33-40	36.2	2.49	6.9
TaIII(H)	18	9	14-18	16.1	1.36	8.5
TiIII/GeIII	1.77	9	1.40-1.80	1.62	0.137	8.5
SA/SP	0.39	9	0.35-0.45	0.400	0.0350	8.8
AW/AMB	1.53	9	1.53-1.89	1.72	0.144	8.4

* For maximum values

coxae and claws). Leg scobalae slender, spiniform.

Leg specialised setae: SoGeI.76d(17), VsGeI.76ad(5), SoTiI.39d(19), SoTiI.88d(16), VsTiI.87pd(4), SoGeII.62d(14), VsGeII.90d(3), SoTiII.36d(11), SoTiII.92d(10), SoGeIII.53d(12).

Tarsus I with FaTaI.53ad(minute), SoTaI.55d(13), SoTaI.85d(13) (arising from a distinct boss). Tarsus II with SoTaII.38ad(15), FaTaII.40pd(2).

Tarsal claws: on tarsus I & II the laterals (a & p) falciform, smooth, equal, empodium (m) slender, curved, over-reaching laterals. On tarsus III anterior claw similar to laterals of I & II, but larger; empodium as for I & II, but longer, over-reaching anterior claw; posterior claw absent.

Gnathosoma: chelicerae bases slender, 42 long by 26 across (combined); digits curved, pointed, simple, about 7 long. Galeala (protorostral seta) slender, spiniform, *c.* 5 long. No deutorostral or tritorostral setae identified, nor basis capituli setae. Palpi slender, femur and genu without setae, palpal tibia with three slender, spiniform setae.

Palpal tarsus a blunt cone, 6 long, by 4 wide at

base; on it three simple slender setae can be identified under oil immersion, longest seta 20 long. Palpal tibial claw (odontus) bifid, the tines curved, lightly separated, blunted, the medial tine the larger.

Etymology

The word *gracilis* is from Latin, for slender.

Remarks On The Classification Of Yurebillidae And *Yurebilla*

The presence of an urstigma (Claparède's organ) in larval *Yurebilla*, and its general facies, clearly defines *Yurebilla* as a member of the Trombidioidea, using this term in a customary sense. The only other larva of the Trombidiformes with an urstigma is *Calyptostoma* (Calyptostomatidae). A variety of other characters has been responsible of the separation of Calyptostomatidae from the Trombidioidea; among those of the larva the presence of multisetose coxae is one of the most notable (see e.g. Shiba 1976). Welbourn (1991) in fact, on the basis of cladistic analysis, groups the Erythraeoidea and the Calyptostomatoidea in a subcohort Erythraeina of the Parasitengona.

None of the characters used above in defining Yurebillidae is unique among the families of the Trombidioidea, all of which are terrestrial. (We may exclude from further discussion the Hydracarina (Hydrachnoidia of Krantz (1978)), on grounds of general morphology, although they clearly derive from a common ancestry with the Trombidioidea.)

Considering the defining characters given above systematically, the first character given is of two eyes on each side. This character is virtually present throughout the Trombidioidea. Two genera in which eyes are absent are *Beronium* Southcott, 1986b, erected for larva parasitic on a cavernicolous beetle, and *Audyana* Womersley, 1954a, a larva which was collected ectoparasitic on a Malayan scorpion, *Heterometrus longimanus* (Herbst), probably largely nocturnal (see e.g. Harrison 1954). The deutonymph of *Audyana thompsoni* Womersley also lacks eyes (Womersley 1954b). This genus was placed in a family Audyanidae by Southcott (1987a).

A prodorsal scutum is present throughout the Trombidiodea, but only a few genera possess a nasus, in disparate groupings, e.g. *Neotrombidium* (family Neotrombidiidae) (Southcott 1954; Lindquist & Vercammen-Grandjean 1971), Leeuwenhoekiinae, family Trombiculidae (many authors). Most trombidioid prodorsal scuta have two sensillary and six non-sensillary setae; exceptions are in the Trombiculidae (e.g. 4 + 2 in Trombiculinae, 5 + 2 in Leeuwenhoekiinae).

A scutellum (second dorsal scutum) is present in various families of the Trombidioidea, e.g. Trombidiidae and Allothrombiidae, and Microtrombidiidae (including Microtrombidiinae and Eutrombidiinae); *Hexathrombium* in the Eutrombidiinae is unusual in having several dorsal scuta. A scutellum is absent in the Trombiculidae, Chyzeriidae (Southcott 1982) and Trombellidae (Southcott 1986a).

Palpal and pedal supracoxalae appear to be unique to the Chyzeriidae among the larvae of the Trombidioidea, but are present in some larval Erythraeoidea, e.g. *Leptus* (see e.g. Southcott 1992).

A mouth-ring, among the Microtrombidiidae, is found in most, but not all, larvae (see e.g. Southcott 1994). The presence of an equivalent structure, i.e. an expanded lip to the mouth, with a number of find adhesive units or pads, is seen in the larval Erythraeoidea.

The coxa I & II of each side are contiguous in almost all Trombidioidea, with the urstigma closely associated with coxa I. In the Chyzeriidae coxa I & II of each side are separated (Southcott 1982).

The coxal setal formula of 2, 1, 1 is found in a number of families of the Trombidioidea, e.g. Podothrombiidae, Trombellidae, Chyzeriidae, Neotrombidiidae, and most Microtrombidiidae (*Keramotrombium*, with 2, 2, 1, is an exception), including the Eutrombidiinae. The coxal setal pattern of 2, 2, 1 occurs in the Trombidiidae and the Allothrombiidae. A nude medial coxala I occurs in *Trombidium* (Trombidiidae), Eutrombidiinae of the Microtrombidiidae, and Neotrombidiidae; a setulose medial coxala I is present in larval Allothrombiidae, Podothrombiidae, subfamily Microtrombidiinae of the Microtrombidiidae, Trombellidae and Wondecliinae. (However, Southcott 1994 recorded the larva of *Microtrombidium nitidum* Southcott as having a nude medial coxala I.)

A leg segmental pattern of 6, 6, 6 is generally present in the trombidioid larvae; Chyzeriidae and Trombiculinae have the exceptional pattern of 7, 7, 7 (i.e. divided femora); in Neotrombidiidae, as well as in the Audyanidae, the pattern is 7, 6, 6 (Womersley 1954a). A reduction of the tarsal claws is common in the Trombidioidea, e.g. with many Microtrombidiidae, and ranging through to

a single pedotarsal claw in larval Neotrombidiidae and Audyanidae. Among the larval Trombidioidea only the family Podothrombiidae has ventral sensory setae (eupathidia, eupathidalae) to the tarsi (Robaux 1977; Zhang & Jensen 1995).

A seta is lacking to the palpal femur and genu in the Allothrombiidae (Welbourn 1991; Zhang & Jensen 1995), as is the case in a number of the Microtrombidiinae (Southcott 1994)); other differences are listed above. The larval Trombidiinae lack only a palpal femorala.

If we accept in broad terms, the cladistic analysis of Welbourn (1991) for the larvae (the adult of *Yurebilla* being unknown), we may exclude it from the Tanaupodoidea on the ground of its lacking a lassenia organ (the only larval criterion given) and from the Chyzerioidea on the ground of its lacking elongate tarsi (again, the only larval criterion given). We must then decide whether to allot *Yurebilla* to the Trombiculoidea or the Trombidioidea, each in the sense of Welbourn (1991). According to Welbourn (1991: 164, 165) the only criterion separating these groups is the presence of "Apomorphy number 8" in the Trombiculoidea, i.e. the presence of seta 'theta on femur legs I, II &/or III'. This presumably refers to a solenoidal seta, on the analogy of setae omega, phi and sigma as used by the Grandjean school of setal terminology. This criterion is not understood, as I cannot find any evidence of such a seta in e.g. *Eutrombicula* or *Odontacarus*. Solenoidalae (=spinalae) are present on the femora of larval *Nothrotrombidium*, family Trombellidae (Southcott 1987a), a family which Welbourn (1991) includes in his Trombiculoidea. We may therefore also exclude *Yurebilla* from the Trombiculoidea.

There appears little point in going through Welbourn's (1984) list of 41 characters in detail, as in 1991 he modified it by reducing the list to 19 characters of larvae and six of adults. In this all Trombidioidea were placed in four superfamilies. Accepting this revised classification, *Yurebilla* may be excluded from the Tanaupodoidea and Chyzerioidea (these separations could be supplemented with other characters), as well as from the Trombiculoidea.

Yurebilla clearly belongs to the Trombidioidea, even as used in the restricted sense of Welbourn (1991), where it is divided into four families. In his earlier cladistic analysis Welbourn (1984) had given as major distinguishing characters 'Apomorphies 45 & 55' for the Trombidiinae and 'Apomorphy 24' for the Microtrombidiinae. Apomorphy 45 is the absence of a 'Distal eupathid (paraxial) on the tarsus of leg I', while the plesiomorphic state is its presence. In *Yurebilla* no such seta is present so that it comes within the 'Microtrombidiinae' of Welbourn (1984). Against this is the other criterion for Welbourn's (1984) 'Trombidiinae', of 'plesiomorphy number 24', i.e. four setae on genu II & III (the apomorphic state being of two setae). In 1991 Welbourn defined his 'Plesiomorphy 10' as being of more than four setae on genu II & III, and 'Apomorphy 10b' as of less than four setae for the Trombidioidea, neither of which applies in *Yurebilla*. Another criterion for Microtrombidiinae is 'Plesiomorphy 55', i.e. of one seta on coxa II, which applies in *Yurebilla* (also listed as 'Apomorphy 54' for the 'Podothrombiini'). In 1991, however, Welbourn included eight subfamilies in the Trombidioidea, including Trombidiinae, Allothrombiinae, Podothrombiinae, Microtrombidiinae and Eutrombidiinae.

One could go through the list of apomorphies and plesiomorphies given by Welbourn in his Figure 1 and Table 1 of 1984, finding characters possessed by *Yurebilla* in various subgroups of the 'Trombidiinae' and the 'Microtrombidiinae', but no set of characters which defines its position uniquely. Apart from the confusion in characters 54 & 55, it may be pointed out that Welbourn's Table 1 contains other errors, e.g. in characters 77 & 78, which disagree with each other, and characters 97–99, which repeat those of characters 49–51.

Despite *Yurebilla* (and Yurebillidae) not matching any of the criteria for family grouping in either of Welbourn's cladistic essays, I believe that it has most resemblances to the Allothrombiidae (Allothrombiinae), and regard it as nearest to that group.

Acknowledgments

I thank the Australian Biological Resources Survey for support.

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TRADITIONAL MATERIAL CULTURE OF THE KUKU–YALANJI OF BLOOMFIELD RIVER, NORTH QUEENSLAND

CHRISTOPHER ANDERSON

ANDERSON, C. 1996. Traditional material culture of the Kuku–Yalanji of Bloomfield River, North Queensland. *Records of the South Australian Museum* **29**(1): 63–83.

This paper describes the material culture of Kuku–Yalanji speaking Aboriginal people in the rainforest regions around the Bloomfield River in south-east Cape York Peninsula, Queensland. The primary emphasis is on 'traditional' material culture, as it was around 1880 before significant European activity began in the area. However, at the end of the paper I deal briefly with some of the changes which have occurred since then and describe Kuku–Yalanji material culture as it was during a period of my fieldwork in the late 1970s.

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The Bloomfield River area is at the northern tip of the band of tropical rain forest that stretches along the coast of north-eastern Queensland from Cardwell to Cooktown. Coastal south-east Cape York Peninsula is a region of high ecological diversity and one with a host of impressive physiographic features. The landscape is dominated by steep-sided valleys, fast-flowing creeks, high thundering waterfalls, huge granite formations and dense rainforest-clothed mountains. The coastline contains some of the largest relatively undisturbed tropical lowland rainforest left in Australia. Near the mouth of the Bloomfield, a narrow coastal woodland plain and a large swamp area separate the mountains from the fine, sandy beach and Weary Bay. The Bloomfield valley is bounded to the north by a series of mountain ranges extending from Mt Boolbun east to Mt Romeo and Mt Hartley. These ranges separate the Bloomfield River from the Normanby and Annan basins, while in the south-west the McDowall Range separates the Bloomfield from the Daintree River. The densely clad coastal range from Thornton Peak to Mt Neville extends up to 1 400 metres in places and forms the south-eastern boundary of the Bloomfield valley. The mountains in the range are also the sources of the Bloomfield River itself. Above the Bloomfield Falls near the Wujalwujal Aboriginal Community, the river is known as Roaring Meg Creek. Roaring Meg begins in the high rocky peaks of Mt Peter Botte and flows north-west, then east in a large arc, past China Camp towards Bloomfield. The creek is characterised by huge granite boulder banks, a series of deep pools and waterfalls beginning west of Mt Peter Botte and culminating in the spectacular Meg Falls. There are five major creek systems that make up the Bloomfield drainage area. The Bloomfield River is tidal for the seven kilometres up to the first waterfall.

In the Bloomfield basin there is a basic division between closed forest and open sclerophyll forest and woodland. The closed vine forest is found primarily at the higher altitudes on both sides of the Bloomfield valley, except for some extensive gallery forests in the major creeks emptying into the Bloomfield River. A channel of open woodland forest some eight to ten kilometres wide follows the course of the Bloomfield River/ Roaring Meg Creek from the coast up to China Camp and over to the Great Dividing Range. The Bloomfield coastline includes several prominent ecozones: vine forests on steep slopes down to the ocean's edge, the beach ridges at Plantation, Kangkiji and Cowie Beaches, areas of saline littoral zone in from Plantation Beach and the mangrove areas at the mouth and on the several islands in the Bloomfield River.

Environmental changes since 1880 in the Bloomfield region due to European activities have been localised and relatively minimal. Selective logging has occurred and the riverine flatlands and the coastal plain in from Weary Bay have been partially cleared for small-scale agriculture. Most of the European enterprises here have been unsuccessful due to labour problems and difficulties in getting products to market. European population levels were always, as a consequence, quite low. The one relatively

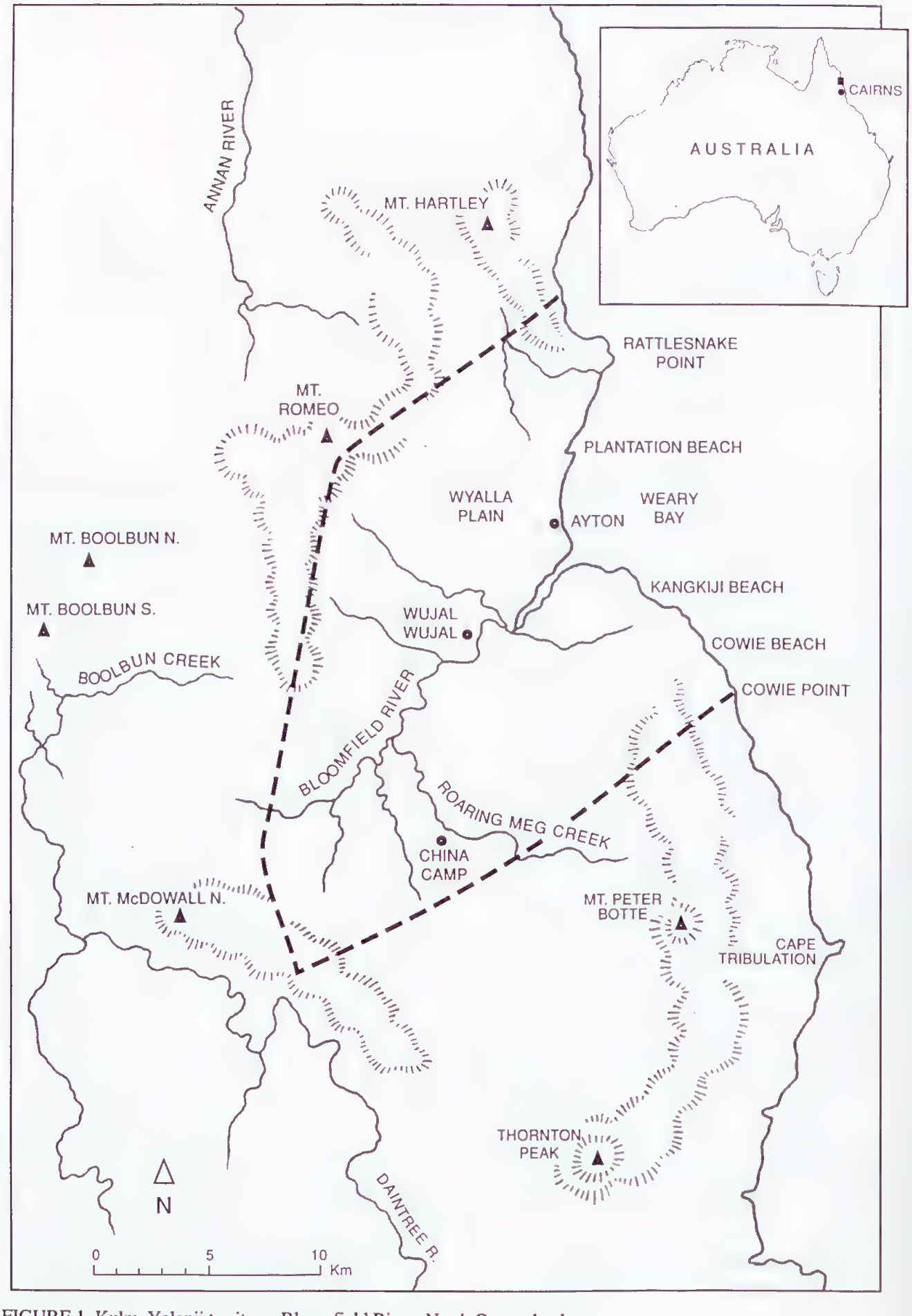

FIGURE 1. Kuku–Yalanji territory, Bloomfield River, North Queensland.

successful industry was tin-mining. Between about 1890 and 1920 there were several large scale tin operations at China Camp and in the high country near Mt Peter Botte. The major environmental effects of this activity were in its local clearing and shifting of tonnes of earth, the destruction and alteration of stream courses, and the use of local timber and firewood (see Anderson 1983).

A total of 224 Aboriginal people were reported for the Bloomfield area in 1886 (Hodgkinson 1886); in 1957 this number had reduced to 133 (Hartwig 1958). In the period of my major fieldwork in the late 1970s and early 1980s, most Kuku–Yalanji lived at the Wujalwujal settlement, then a Lutheran Church-run mission on the Bloomfield River (260 people in 1980—Anderson 1982). A few Kuku–Yalanji people also lived in Daintree, Mossman and Cooktown. Figure 1 shows the area occupied and used by the Kuku–Yalanji until their centralisation at the mission in the late 1960s. It also shows the permanent camps which existed on the Bloomfield until the mission began and which were used on an regular basis in the late 1970s.

I use the term 'Kuku–Yalanji' to refer to the people who lived on the coast between Rattlesnake Point and Cowie Point, and along the Bloomfield River and its tributaries west to the Great Dividing Range (see Figure 1). My term is thus equivalent to Roth's (1910) 'Koko–balja', McConnel's (1939–1940) 'Koko–yanyu' and 'Koko–yalunyu' and Tindale's (1974) 'Jungkurara'. Roth's term is actually the name for the Kuku–Nyungkul–speaking people of the Annan River to the north of Bloomfield. McConnel's terms are ones which literally mean 'language in which the demonstrative pronoun is 'yanyu/yalunyu' in the coastal and inland dialects respectively. Tindale's term is a clan name for a group associated with the Butcher's Hill–Lakeland Downs area 100km to the north west of Bloomfield. Roth (1910) describes the Butcher's Hill tribe as being called 'Koko–yerlan–tchi'; whereas Tindale (1974) says 'Koko–jelandji' was the tribe associated with the upper Palmer River area.

These and other sources describing the tribes of south-east Cape York Peninsula often confuse language names with clan and larger group names. Aboriginal people in the Bloomfield area had no formal, overall ('tribal') name for themselves, only names as members of this or that clan. Further, their language had no name as such either, other than descriptive labels such as those applied by McConnel. At least by the time of Roth's first visits in 1898, they had become known by the English label, the 'Bloomfield River Aborigines'. Although there is no equivalent term in the Bloomfield language for such a term, it does seem to have been an isolable cultural unit and can be opposed to other similar ones in the area, eg. 'Annan River group', 'Daintree River people', etc.

Confusion with respect to names in this area stems from two other sources. Firstly, the names given above by Roth and Tindale for groups to the west and north-west of Bloomfield, were actual tribal and language names, at least according to Aborigines from that region in the late 1970s (Brady *et al* 1980; Anderson & Mitchell 1981). Secondly, the Bloomfield Aborigines were part of a large, linguistically homogeneous bloc, extending from just south of Cooktown, west over to the Middle Palmer River, south to Chillagoe and east to Mossman on the coast. Languages spoken in this area, including the Bloomfield ones, Muluriji, Wagaman, Jangun and Kuku–Nyungkul, are all dialects of the same language. There were also cultural similarities between groups in this area. However, I reserve the term 'Kuku–Yalanji' exclusively for the nineteen or so clans that occupied the immediate Bloomfield River valley. I use the term because it is one used in the 1990s by this group sometimes to refer to themselves. It is one that has also gained some usage in the literature (Patz 1982; Hershberger & Hershberger 1982).

Kuku–Yalanji material culture is of interest for a number of reasons. Firstly, the area's topography brings rainforest, riverine and coastal environments into close proximity. This meant that Kuku–Yalanji were able to exploit a range of resources over short distances for subsistence and for manufacture of material culture items. This in turn led to substantial camps of a semi-permanent nature. Under such circumstances certain aspects of material culture, shelter for example, were elaborated. Secondly, Bloomfield as the northern boundary of the coastal rainforest zone in north Queensland, may also have been the limit of material culture associated with that environment elsewhere. A full description of Kuku–Yalanji material culture would provide a basis for comparison with other rainforest cultures along these lines.

Thirdly, reconstruction of pre-1880 Kuku–Yalanji seasonal rounds and movement overall, demonstrate that travel occurred over a very limited area, especially for coastal and riverine

peoples. This isolation is reflected in several unique material culture items and subsistence techniques, including curvilinear lath spear throwers and the use of boiling in cooking. Fourthly, the notion of personal property with respect to material culture items and resources seems to have been particularly well developed at Bloomfield. Finally, while the overall repertoire of 'traditional' material culture was considerably reduced by the late 1970s, this did not reflect a drastic transformation of the Kuku–Yalanji economy. All major traditional economic activities continued to be undertaken, using many traditional and slightly modified tools and implements. These activities were also carried out using many items of wholly European origin. Overall, there was significant maintenance by Kuku–Yalanji of knowledge about traditional material culture and, as well, continuities in the usage of items themselves into the late 1970s.[1]

Kuku–Yalanji settlement patterns and general resource use

An important distinction made in Kuku–Yalanji culture was that between the environments, resources and people associated with the sea and those associated with inland areas. The range of potentially exploitable environments in the Bloomfield coastal region was very great. Significant ones for coastal Kuku–Yalanji were the marine reefs and shallow water areas, islands and coral bays, beaches, freshwater and tidal creeks, mangroves and swamps, littoral thickets, lowland rainforest and open woodland forest. Each of these environments provided different sets of resources which were exploited on a permanent or seasonal basis. About every four to five kilometres along the coast near Bloomfield, nestled between the areas of rocky, steep and uninhabitable shoreline, are small bays and coves with white sandy beaches with one or two freshwater creeks emptying into them. These beaches were the focal points of residence and economic life for coastal Kuku–Yalanji. During both the wet and dry seasons, camps containing permanently maintained shelters were located on these beaches.[2] Aboriginal movement was primarily north and south between these permanent camps with seasonal forays inland up onto the coastal ranges for wallaby, yams and tubers, and wild honey, and to freshwater streams for eelfish and freshwater tortoise. The beach and tidal zones also provided abundant fish and shellfish.

In the inland areas around Bloomfield, three types of environment were habitually exploited: upper montane and riverine rainforest, open eucalypt and woodland forests and the freshwater creek systems. The latter were undoubtedly the focal points of economic life for inlanders, where good sandy campsites, shade and proximity to freshwater year-round could be found. Dry season camps were in the sandy beds of the smaller dry creeks or on the sandy terraces above the running creeks. The wet season camps were generally on the ridges between creek gullies, well above flood level, but not too far from water supplies. The pattern of movement in the inland areas was one of short distance shifts within a series of major camps along the creeks. In the dry, the smaller nuclear family-based groups would move out away from the main camping areas and set up temporary 'branch' camps in order to exploit non-seasonal opportunistic resources such as eelfish, tortoises, wallabies and goannas. In the wet, the tendency was to contract into larger more permanent camps. Large camps with up to 100 people also existed in the dry during the harvesting and preparation of seasonal, bulk-supply resources such as cycad nuts.

Kuku–Yalanji subsistence activities and material culture

In this section I describe Kuku–Yalanji material culture within the context of three major categories of subsistence activity. The first of these is hunting. Kuku–Yalanji hunting on land was essentially a solitary affair, with at most two men going out for one to two days. The exception was the large-scale wallaby drives undertaken in the dry season. These involved both young and old men, and occasionally women. Fires were carefully lit to create a 'wall' of fire going in one direction with only a few openings. Young people, starting within a forested area, walked in a long line beating the bush and shouting. This drove kangaroos, wallabies and other smaller animals towards the gaps in the fire, where the older men waited with spears (see Le Souef 1894: 13; Hodgkinson 1886: 11; and Roth 1901: 29). Apart from kangaroos and wallabies, the major meat-resource animals which were hunted included small mammals, reptiles, birds and cassowaries. The Bennett's tree-climbing kangaroo, *Dendrolagus bennettianus* (only found in this area), was tracked by sight or with the use of dogs

TABLE 1. Kuku–Yalanji spears

Kuku–Yalanji Term	*Purpose*	*No. of Prongs*	*Point*	*Handle*
jindal	hunting	3	wood (*Acacia* sp)	*Normanbya normanbyi*
wurrbuy	hunting	1	wood (*Acacia* sp)/ bone	*Xanthorrhoea arborea* proximal *and Acacia holocarpa* distal
murrangkal	hunting	1	wood (*Acacia* sp)/ stringray barb	*N. normanbyi*
yingkan	hunting	1	quartz pieces	*N. normanbyi*
bukul–bukul	hunting	1	wood w/stingray barb	Reed or bamboo proximal and *N. normanbyi* distal
duwar	hunting	1	wood *N. normanbyi*	Reed proximal and *N.* normanbyi distal
yinba	fishing	3–4	wood (*Acacia* sp)	*N. normanbyi*
yirrmba	fishing	4–7	wood (*Acacia* sp)/ bone	*Xanthorrhoea arborea* or bamboo
dikarra	fighting	3–5	stingray (pointed forwards)	*Xanthorrhoea arborea* proximal and *N. normanbyi* or *Acacia* distal
kuyan	fighting	1	quartz pieces	*N. normanbyi*
dajal	fighting/ hunting	1	stingray (pointed backwards)	*Xanthorrhoea arborea* proximal and *N. normanbyi* or *Acacia* distal
bandi	fighting	1	wood (*N. normanbyi*)	*N. normanbyi*

(see Le Souef 1894: 13). Other kangaroos and wallabies were stalked from down wind at times and places where they were known to graze, rest or come for water.

Twelve varieties of spears, including hunting ones, were used on the Bloomfield. These were classified by Kuku–Yalanji according to the number of prongs, the nature of the prongs, whether or not a barb or stone tip was present and what the spear handle was made of. Kuku–Yalanji spears are shown in Table 1.

These were nominal categories in most cases. Most spears could be used for any purpose if necessary. Examples of the single and multiple-pronged, barbed and unbarbed spears are in the collections of the Queensland Museum and the Australian Museum (except that the multiple-pronged, non-barbed spears sometimes have wire prongs). These vary in length from 2 300 mm to 2 915 mm. Le Souef (1894: 27) noted that the Bloomfield spears were up to 9'6" (2 900 mm) in length. A specimen of the quartz-tipped spear from Bloomfield is in the Roth collection of the Australian Museum (Kahn 1993: 151–2). Roth (1909: 193) describes how the quartz flakes were attached to the spear's end. For the wooden-pointed spears, Cooktown ironwood (*Erythrophloeum chlorostayches*) was sometimes used as the point and distal end instead of the black palm (*Normanbya normanbyi*). In either case they were fire hardened after sharpening. The stingray barbs and the multiple-prongs were held in place by wallaby sinew and resins made from *Canarium australiasicum*, *E. chlorostayches* or grasstree *Xanthorrhoea johnsonii*) (see Kahn 1993: 149; Idriess 1934: 145; Le Souef 1894: 27, and Roth 1904: 11, 1909: 192–193).

For hunting, a linear or ovate lath spear thrower of *E. chlorostayches* was used. These spear throwers (termed, in Kuku–Yalanji, *milbayarr*) were very plain, usually with no shell attachment or handle. They varied in length from 0.9 m–1 m, and were from 60 mm–90 mm wide, according to the specimens in the Queensland and Australian Museums and the ones made at Bloomfield today. There are numerous scarred trees in the Bloomfield area where wood for these spear throwers has been cut out.

The other major type of hunting, at least on the coast, was for marine turtle (primarily *Chelonia mydas*). Turtle hunting was a wholly male domain and it took at least two and generally three men to conduct a hunt. One or two were needed to paddle the canoe and watch for turtles, while the other man stood on the prow of the boat with harpoon in hand and guided the boat with hand signals

depending on turtle movements. When a good-sized turtle was sighted, the prow man let fly with the harpoon, one hand pushing the end of his whole body weight behind it. This was followed, usually, by the man diving into the water, guided by the path of the rope, then diving underwater to turn over the turtle—with the harpoon point in his neck or tail. Man and turtle would then float to the top and the turtle would be hauled into the canoe.

The harpoon apparatus was made up of a handle up to three metres long made from the mangrove *Rhizophora apiculata*; a harpoon point which was a sharpened and fire-hardened point some 10 cm–15 cm long made from *Acacia crassicarpa* or sometimes *Erythrophloeum chlorostayches*; and a connecting rope made either from the smashed and twisted bark of *Sterculia quadrifida* or of *Hibiscus tiliaceus*. The point was not barbed and thus great skill was needed in throwing the harpoon so that it went into the softer portions of the turtle. The point was stuffed into the hollowed-out end of the handle and kept there by a ring-plug of gum (usually *Canarium australiasicum*). This ring also acted to keep the rope attached to the point as the harpoon handle came out on impact and floated to the surface. Apart from being attached to the point, the rope was run through a hole in the flattened and bored out end of the handle and from there it was coiled up in the bottom of the boat's prow.

The boats used were outrigger canoes with a single outrigger on the starboard side (see Figure 2). A variety of timbers were used in the construction of the dug-out portion, but *Aleurites molucanna*, *Toona australia* and a 'cotton tree' (probably *Bombax malabaricum*) seem to have been most favoured on the Bloomfield coast. The trees were cut down with stone axes, and the inside burned out and scraped clean with adzes. The outrigger was attached with lawyer-vine. The canoes were poled in shallow water and paddled in deeper water. Paddles were made from *Xylocarpus granatum*. Bailer shells were used to keep excess water out. The canoes were up to seven metres in length and could carry six to seven people or two men and two large turtles. P. P. King, during his navigation of the east coast of Queensland in 1819 and in 1821, found several of these canoes at Bloomfield. Full descriptions are in his journal (King 1827, Vol. 1: 208–209; Vol. 2: 14). Hershberger & Hershberger (1982: 106) and Oates and Oates (1964: 110) state that the Kuku–Yalanji term *mararr*, which in the 1970s was used to refer to cloth, had originally meant a sail made of plaited palm leaves. I have no other evidence of the use of sails on the canoes.

The next category of subsistence activity I want

FIGURE 2. Kuku-Yalanji people in outrigger canoes on the Bloomfield River near the mouth of Thompson Creek, 1904. Photograph: A. A. White. John Oxley Library Collection.

to examine is fishing. Fish was one of the most important components of the Kuku–Yalanji diet, especially on the coast. This resource was available at any time, to be exploited opportunistically by the Kuku–Yalanji whose knowledge of fish behaviour and habits enabled them to do so easily. There were three main ways of obtaining fish. The first was by spearing. This was normally men's work and it was done out on the reef at low tide, from the edges of a creek bank, in the water or while standing on an overhanging branch. In freshwater creeks and waterholes, eelfish were sometimes speared from underwater. 'Night-fishing' also occurred. This was done on the tidal estuaries from a canoe at night. One person sat at the front of the boat holding aloft a burning paperbark torch. As the fish were attracted to the light, another person would spear them. One of the most important species of fish and one which could obtained only be spearing was mullet. In the late dry, shoals of mullet, particularly *Mugil cephalus* and *Valamugil seheli*, came into the creeks and up the river. At other times rock cod, coral cod, red emperor, black-tip shark and stingrays were commonly speared. The latter species was important not only as a meat source, but for the supply of spear barbs. It is significant, too, that the spearing of stingray was surrounded by restrictions. Only adult men could obtain it, and even then never in the presence of, or with the knowledge of their wives' brothers (actual or classificatory).

Multi-pronged spears were normally used, the most common being the *yirrmba* (see Table 1), with a grasstree or bamboo handle and a hardwood or bone point. A special spear thrower was used for fishing, and as it is unique to Bloomfield it is worthy of a full description. The Kuku–Yalanji fishing spear thrower, known as a *balur*, was a curvilinear lath 650 mm–800 mm in length and 50 mm–70 mm wide. There are 14 specimens in the Queensland Museum collection and a similar number in the Australian Museum. Descriptions of the spear throwers are given by Kahn (1993: 152–3), Le Souef (1894: 27) and Roth (1909: 199). Roth states:

> The ballur is employed for spearing fish or birds with, especially anything at very close quarters. It is comparatively short, made of a light timber, is haftless, and generally decorated with red and white pigment at its distal extremity. It is thrown in a manner different from all other woomeras, in that the blade rests in the fork between the first finger and the thumb, instead of, as in the ordinary style, between the first and second fingers.

The timber generally used for these spear throwers was *Argyrodendron* sp (Robins 1984). From my observations of Kuku–Yalanji use of the spear throwers at Bloomfield in the late 1970s, the peg at the end for holding the spear was varied in length and angle according to distance and the personal requirements of the thrower (see Figure 3).

The second method of fishing was with a hook and line. Spear fishing could only be done in relatively clear water. Fishing with hook and line on the other hand, could be done in the river and estuarine creeks year-round even when the water

FIGURE 3. John Walker holding a *balur* (spear thrower) on the Bloomfield River, 1978. Photograph: C. Anderson.

was muddy. The line was made from the smashed, twisted and twined bark of *Hibiscus tiliaceus*. The hooks used in salt water were shell-hooks made probably from pearl shell (*Perna Cumingii*). Kuku–Yalanji in the late 1970s had no knowledge of how the hooks were made and none existed at Bloomfield then. Rowan (1912: 110) found one on the banks of the Bloomfield River in 1892; Roth (1904: 33) describes them generally for south east Cape York Peninsula. Just south of Bloomfield in 1821 in a deserted coastal camp, King found 'a fishing rod, and a line five or six fathoms long [nine to eleven metres], furnished with a hook made from a shell' (King 1827, Vol.2: 14).

Lines were held by hand or tied to a stick set into the sand or the bank. Bait could consist of pieces of less preferred fish (eg. a small grunter or shark), small crab, frogs or small shellfish. The most common fish species taken by hook and line were the various species of bream, trevally, mangrove jack, sea perch and barramundi.

In freshwater creeks and waterholes, lines were used for turtle, eelfish, catfish and perch. Here the lines were made from the bark of *Sterculia quadrifolia* and the hooks from the thorn of the lawyer cane *Calamus australia* (see Idriess 1934: 185). Bait was generally grubs, small freshwater prawns or small frogs. Both on the coast and inland, line-fishing was seen as primarily a woman's task, but men did it occasionally.

The third method of obtaining fish was by use of plant stupefacients. This was a common technique in the inland areas in the late dry season as some of the smaller creeks dried and became a series of isolated waterholes. Several trees were used as sources for these fish 'poisons'. With *Erythrophleum chlorostachys*, the bark and leaves were smashed together under water; with *Barringtonia asiatica*, the seeds were mashed up together with a grass sponge which was then shaken and swirled under water; while with *B. racemosa*, the stems were used in this manner. These poisons stunned or blinded the fish and they then floated to the surface where they could be collected. The divers had to close their eyes very tightly as they worked and be careful not to swim through any of the substance in the water. The waterhole was then unusable until after a storm and flood renewed the water.

The third and final subsistence category to examine is gathering. One important gathered seasonal resource was fruit. At least fifty major species were considered desirable by Kuku–Yalanji. Most of these ripen in the period May to August, and most are found either in rainforest, on its margins or within gallery forests along the major creeks.

Important species included quandong, Burdekin plum, wild almond and several species of *Eugenia* and *Ficus*. Collection of the fruit was often as an adjunct to some other production task, for example men while hunting, or women while fishing. Long sticks were often used to knock down fruit from the taller trees. Bark troughs or dilly bags were used for carrying of the fruit. Some fruit such as certain *Ficus* species and the quandong could be kept for several weeks after being dried in the sun, while others such as the Burdekin plums could be force-ripened by burying them in the ground in a dilly bag and left for up to a week.

Nuts were another gathered resource and around ten important species were utilised on the Bloomfield. I will describe later the material culture items used for preparation of these nuts. Tubers, bulbs and wild yams were the cornerstone of the Kuku–Yalanji diet, especially in the inland area. Most of these were available from the mid-dry season until November or so, but others were available in the wet season. Important species were *Tacca pinnatifida*, *Typhonium brownii* and four varieties of *Dioscorea sativa*. One of the latter, *Dioscorea sativa*, var. *rotunda* or 'hairy yam', was probably the most important vegetable food item in the Kuku–Yalanji diet and was the mainstay of meals for up to five months. Both men and women could dig the yam, but if dug by men then women could not eat them. In practice it was women who supplied the bulk of this resource (see Hodgkinson 1886: 10). These yams grew in the sandy-soiled, open forest country, on the edges of swamps and on the river and creek banks. They were dug out with one of the most important subsistence tools at Bloomfield, the so-called digging stick. The author Ion Idriess, who lived at Bloomfield for several years before the First World War, described this item:

> Like all their simple tools, [the stick] has a surprising number of purposes... as a digging stick for uprooting vegetable foods, as a prodder and level for forcing small animals (snakes, lizards, birds) from log or burrow or tunnel in river bank, as a 'border' for water. Primarily, though, it is a digger of yams... About five feet long [1.5 m], a heavy, well-seasoned staff of hardwood, it tapers at one end to a point, and this makes a very efficient tool... (Idriess 1980 [1959]: 251; see also Roth 1904: 24).

Once dug, the hairy yam, as with many of the vegetable foods in the Kuku–Yalanji diet, needed extensive processing. This is described below.

Apart from fruit and vegetables, a host of other resources were gathered in this area: shellfish, terrestrial snails, insects such as green ants and their eggs, scrub fowl and bush turkey eggs, mangrove worms and so on. None of these activities required any special material culture items nor any special process. Two significant resources requiring special tools were tree grubs and wild honey or 'sugarbag'. In both cases trees had to be either cut down or chopped up. The grubs were the larvae or pupae stages of moths which live in rotten or fallen trees. The large ones, particularly those found in the candlenut tree, were relished food items; the smaller ones, and ones from certain 'poison' trees, were used as fishing bait.

Throughout the dry season sugarbag was an important and highly desired resource. Nine species of indigenous bee found in south–east Cape York Peninsula were recognised by Kuku–Yalanji as producing honey. Sugarbag was located either by chance sighting of bees going into and out of a hole in a tree or by following bees back to the nest. Idriess (1980 [1959]: 246–247) describes how Aborigines at China Camp attached a 'streamer' of bush cotton to a bee's body. This streamer made a loud hum as the bee flew and it was easy to then track it to the hive. During the late dry, the bases of trees known to be favoured by the bees were examined for bee dung, and also tapped for hollowness. If located and if the nests were low enough, the hole was simply made bigger and the comb extracted, sometimes with the use of a hooked swab made of lawyer cane. The honey was then placed in a bark container. When the nests were high in the tree, grass ropes were made for climbing.

Alternatively, in some trees steps were cut on each side for easier climbing. I noted such steps on many trees in the Bloomfield area in the late 1970s. Sometimes the entire tree was chopped down. Le Souef (1894: 27) notes: 'It is surprising to see how hard the [Bloomfield] blacks work in cutting down a big tree to get a hive, otherwise out of reach, as they are very fond of honey'.

Hafted stone axes were used to obtain both the grubs and the bee hives. The celts were tied onto a handle made of a portion of large lawyer cane and secured there by bark fibre or wallaby sinew and a gum mixture of beeswax mixed with resin from *Canarium australasicum*. The resulting axe was reported to me by Kuku–Yalanji in the late 1970s to be able to cut down softwood trees up to a metre in diameter and hardwood trees up to about 40 cm. With hardwood trees, a downward stroke chop was used (as opposed to a horizontal chop) which progressively split the tree layers. Examples are in the Australian Museum collection (Kahn 1993: 135–136).[3]

Camps and domestic life

As I noted earlier the focal points of Kuku–Yalanji residence were the sand beaches on the coast and near the main freshwater creek systems inland. At both types of site, shelters were of two basic types: temporary shades and windbreaks; and permanent dome-like huts. For much of the dry season Kuku–Yalanji people used no form of shelter at all, preferring instead to sleep close to fires out in the open campsite.

Windbreaks, made from large branches of any available trees, were set up sometimes for privacy between sections of camps, or to protect the site from strong winds, particularly on the coast. The dome huts were built at the inland camps mainly during the wet season, whereas on the coast they appear to have been maintained year-round, and only refurbished when necessary. The basic form was the same for coastal and inland huts (see Figure 4). Le Souef provides a first-hand description:

> The natives made our humpy of fan palm leaves—first a framework was formed of light saplings bent over and fastened together, and then the large leaves of the palm laid on; these made a rain proof dwelling, and all those of the natives in this district were made in the same way, but covered with whatever they could get nearest at hand, either the leaves of the Fan Palm, Lawyer Palms, grass or bark. The size depended on the number of inmates; but the natives here make their dwellings considerably larger than [elsewhere in north Queensland]. Le Souef (1896: 154)[4]

Roth (1910b: 59-60) also gives a similar description for south-east Cape York Peninsula structures in general. He notes that at Bloomfield the leaf thatching was put on from the top down, with logs and bark sometimes placed on top to act as weights. Also he states that a fire was normally built inside the huts and that they sometimes had one or more entrances.

> Thus on the Bloomfield River, a man with one wife and a small family will occupy a hut with a single entrance; if he has one old wife, and other wives and children, a larger habitation will be used, the old woman having a separate entrance and separate fire to herself. (Roth *ibid*).

Kuku–Yalanji people during the late 1970s informed me that young saplings of the Burdekin plum tree (*Pleiogynium timorense*) were particularly favoured for hut construction, but that any flexible saplings would suffice. For the inland huts, if palm leaves were unavailable, bark from the 'Messmate' tree, *Eucalyptus tetrodonta*, was used. Sheets were cut and peeled off the trees when the sap had arisen after the first storms in December. These sheets were pounded with stones and smoked with the fire until flat. McConnel (1931: 9–10) notes that on the Bloomfield, house building was normally the job of the woman.

Fire was a central part of domestic camp life. It was made by means of a fire-stick by men (although sometimes by women at Bloomfield; see Roth 1904: 10). This fire-stick had two components: a thin wand of about 30 cm and a flat, wider piece of wood about half this length.[5] The wand was twirled vertically with the palms of the hands while the base of the wand was set in a small notch in the flat piece, which lay flat on the ground. The friction created smouldering ash which caught alight with the addition of dry grass and wood particles. Dry grasstree sticks could also be used.

Collecting firewood was usually women's work and different woods were used for different purposes. If conditions were rainy and damp, wood from the 'kerosene tree' (*Halfordia scleroxyla*) made an excellent fire starter. Inner portions of bark from the forest paper bark tree (*Melaleuca leucadendron*) could also be used for this purpose. Dead branches from the grey boxwood (*Eucalyptus tessellaris*) made the best cooking wood: it is very hard, but splits easily and burns slowly and intensely. Some wood was very dangerous to use as firewood. For instance, a mangrove species, *Excoecaria agallocha*, produces a smoke which is said by Kuku–Yalanji to produce blindness. This is also true of the 'brown cedar', *Canarium australasicum*.

The camps were the usual sites for food preparation and consumption. Below I discuss several major Kuku–Yalanji food items, their preparation processes and necessary implements.

Preparation of cycad nuts

During the mid to late dry season, a staple food

FIGURE 4. Dolly Yougie (right) and Eileen Walker (inside), making a wet-season shelter at Plantation Beach, 1982. Photograph: C. Anderson.

item was *Cycas media*. This plant grows prolifically at several locations in the Bloomfield area. When the ripened nuts fell off they were gathered and brought back to a central processing site, ideally beside a shallow, but fast-flowing section of creek. More important were the large flat rocks with small indentations in them, found adjacent to the creek. These were necessary for grinding purposes and were known in Kuku–Yalanji as *jinali*. Their locations were widely known and the sites associated with them used each year. The main grinding surface was usually on the top of a large boulder in the creek itself. Thus during the harvesting and processing time large central camps were set up at these sites.

The women did the processing, while the young men kept the camp supplied with food items such as meat and sugarbag. The first stage of the processing was the roasting of the nuts on the fire, which cracked open the soft outer shell. This was peeled off and the remaining kernel then left for several days prior to grinding. The delay was said to make for easier grinding. The kernels were then ground in the small indentations on the *jinali* using a round, fist-shaped stone. The coarse particles remaining after the initial grinding were then separated from the flour with a small grass 'brush' for further crushing (see Figure 5). This process of grinding and separation continued until only a fine flour was left. Sometimes a closely woven dilly bag was used as a sifter. Roth provides an excellent description of the remaining processes:[6]

> The flour is... put into a grass dilly-bag, which has been previously folded sideways upon itself so as to form a basin-like receptacle and placed near a stream. With the help of leaves [pandanus or wild ginger] acting as a trough, water is allowed to continue flowing into the receptacle, matters being so regulated that the water never overflows the edges. Fresh water is thus continually percolating through the Zamia flour in its dilly-bag colander, right through the night, and in the morning it is ready to be eaten. It may, however, be kept for some three or four days, up till which time it is believed to improve... (Roth 1901: 11).

Hodgkinson (1886: 8) provides a similar description. Some Kuku–Yalanji people in the late 1970s still had detailed knowledge of this process. Also, the stone implements are still *in situ* at several of the sites despite their lack of use for some thirty to forty years.

FIGURE 5. Dinah Stumpy grinding cycad nuts into flour, Ayton, ca 1962. Photograph: H. Hershberger.

FIGURE 6. Louisa Smith making a *balji* (dilly-bag) with black palm fibre strands. Wujal Wujal, 1982. Photograph: H. Hershberger.

The two dilly-bags used in the above process represent two of the three main types of bags at Bloomfield. The first bag was made from fibre strands obtained from the perfoliate bases of the leaf-petrioles of the black palm, *Normanbya normanbyi* (see Figure 6). The second type of dilly-bag was made from the grasses *Xerotes multiflora* or *X. loniflora*. The palm bag was made with two continuous strands chained together and several straight basal strands, while the grass one was made with one continuous strand, in the 'hour-glass' pattern. These two bags were important items and apart from their role in various preparation processes, women used them for carrying anything (including infants). The third type of bag was a men's bag, termed a *ngunyin*, and was made from *Ficus* fibre-twine. It was said by Kuku–Yalanji to have been able to stretch big enough to carry a small wallaby. Otherwise men carried in these bags personal items such as a small stick with ironbark or other gum attached to the end, firesticks wrapped in paperbark, spare spear barbs, and medicinal or sorcery-related items[7] (See Roth 1901b: 8,10; 1904: 28; Kahn 1993: 105–111; Idriess 1980 [1959]: 242).

Preparation of other nut species

Most of the nut species used as subsistence items required some form of preparation. The major species are shown in Table 2. The most highly desired species was the candlenut, *Aleurites moluccana*, which, in addition to being

TABLE 2. Major nut species eaten at Bloomfield and preparation requirements.

Kuku–Yalanji Name	Common English Name	Botanical Name	Roasted on fire	Baked in ashes	Sifted in dilly-bag	Pounded with stones	Leached
jajikal	Screw palm	*Pandanus spiralis*	No	Yes	No	Shell broken first	No
babur	Matchbox bean	*Entada scandens*, Benth.	No	Yes	No	Yes	Yes
bilar	Candlenut	*Aleurites moluccana* (Linn.) Willd.	Yes	No	No	No	No
baway	Moreton Bay chestnut	*Castanospermum australe*, A. Cunn	No	Yes	Yes	Yes	Yes
junda	Wild almond	*Prunua turnerana* (F.M. Bail) Kalkm	No	Yes	Yes	Yes	No
bujabay	Queensland walnut	*Endiandra palmerstonii* (F.M. Bail) C.T. White	Yes	No	Yes	Yes	Yes

eaten on their own, were added to wallaby carcasses to add flavour during cooking. On the other hand, some species such as the matchbox bean, *Entada scandens*, were not particularly relished and only eaten if nothing else was available (see Hodgkinson 1886: 4; Roth 1898b: 2). Although most species were arduous to prepare for minimal return, the advantage of nuts was that they could gathered and kept for up to two months. In the wet season—a time of great dependence on nuts—this meant fewer trips out and away from camp during a time of heavy, continuous rain and reduced mobility due to swollen creeks and rivers.

Yam preparation

Preparation of the otherwise toxic *Dioscorea sativa*, var. *rotunda* or hairy yam also involved the use of a dilly-bag for leaching. Once dug the yams were taken to a processing site—once again, near a small, rapid creek—and clinging roots and dirt were removed from them. They were then baked in a stone oven for several hours until soft and cool. The yams were then mashed by hand in a palm-fibre dilly-bag. After the mashing process, the bag was held over a bark trough and water poured into it to allow the substance to be strained. More mashing, pouring and straining was done until only the rough fibres and skin strands were left in the bag. This residue was then thrown away. More water was added to the bark containers and they were allowed to sit for some time as the yam substance sank to the bottom. Within a short time, an oily substance appeared on top of the water. This was said to be the 'poison', and it and the water were then poured off. Fresh water was then added and the process repeated again a number of times over several hours until the water was completely free of the oil and any bitter taste gone from the yam substance. A crater-like hole about a metre across was then dug in the ground, and clean white sand placed in it. A rolled, large round leaf was put into the bottom of the hole to channel the water away. The porridge-like food was then eaten on leaf plates.[8] Several other yam species were eaten on the Bloomfield without any need for processing other than roasting on the fire. Wild arrowroot, *Tacca pinnatifida*, and another tuber, *Typhonium brownii*, on the other hand, both needed alternate roasting and pounding between two stones in order to be edible. Several of the yams and tubers could be dug and kept without processing for two to three months into the west season.

Cooking processes and associated implements

Many meat items, including reptiles, birds, wallabies and other marsupials were cooked straight on the fire after their bodies had been bashed with an axe to break the bones (see Le Souef 1896: 157). Larger animals such as marine turtles, cassowaries and eelfish were butchered and the meat cooked in a stone oven. Certain round rocks which were known not to crack were placed in a hot fire. Meanwhile a hole was dug near the fire. When the stones were hot, they were picked up with lawyer cane tongs and placed in the hole (see Kahn 1993: 120). The meat, along with *Eucalyptus*, *Acacia* or wild ginger leaves for flavouring, was then put into a bark trough which was placed on the rocks in the hole. Other hot rocks were put around the trough and onto the meat itself. Ti-tree bark was placed over the trough and onto the meat itself. Ti-tree bark was placed over the trough and rocks, than all was covered with sand or earth and left to cook for several hours.[9]

The bark troughs used in the above form of cooking were another important and widely used item of Kuku–Yalanji material culture. Examples are in the Australian Museum collection (see Kahn 1993: 101–102). They were made from the bark of various *Eucalyptus* species, *Curcuma australasica* or *Tristania suaveolens*. If these were not available, dry bark sheets from the palms *Archontophoenix Alexandrae* or *Normanbya normanbyi* could be used to make a temporary trough. With the normal troughs, the bark was soaked in water then bunched up at each end into a kind of 'spike'. Apart from use as a cooking utensil, the troughs were used for carrying water, honey or vegetables, for preparing various species of fruit in (mashing and mixing with water), for carrying infants in and for ferrying things across swollen creeks.

Two other cooking processes are worth mentioning. The eggs of the scrub fowl (*Megapodius freycinet*) were a major dry season protein source. They were wrapped into a 'bag' of big round leaves which had been extensively soaked in water. This bag was then buried in the ashes of a hot fire and left to roast. Boiling was also practised on the Bloomfield, in a number of ways. It was sometimes done in water-soaked bark troughs which sat directly on the fire. Kuku–Yalanji people in the 1970s informed me that an alternate method was to place red–hot rocks into water in the troughs to achieve the same result. The most widespread method of boiling, though, was in the large *Melo umbilicatus* shell (See Roth

1901a: 8; and Kahn 1993: 103–104).

Other domestic implements, games, musical instruments and raw materials

Apart from those already mentioned, a range of other domestic implements were used in the Kuku–Yalanji camp. Spoons were made from a variety of materials. The most valued ones were those made with the scoop of nautilus or melo shells. Unmodified mussel shells were used as more temporary spoons or scoops. These shells, especially *Geloina coaxans*, were also used as scrapers (to remove ashes from cooked meat, for instance), or as a cutter. Only live shells were used to make these implements as dead ones cracked unevenly when worked. Small personal knives were made from short pieces of wood with a quartz end. Leaves, especially those from palm leaves, were used as scoops, plates and water carriers. Fan palm leaves were used as 'tablecloths' and as seats and bunches of long bush grass served as mattresses on hard ground. Sheets of *Melaleuca* also sometimes served these same purposes, and additionally were used as blankets in cold weather. Dry bottlebrush stems were sometimes used as torches around camp and were said to burn for some time. Cassowary feathers were used as fly and mosquito swatters.

String games, using fibre and human hair twines, were played by adults and children. Young boys and girls played a game called *birray*, or 'March fly', in which they chased each other while buzzing like the fly. Young men held diving competitions from tree branches into the water and also held wrestling matches. Toy canoes were made from bark and palm leaves and small toy 'boomerangs' were made from pandanus leaves. Another well-documented Kuku–Yalanji game was one in which a small wheel (made of a log of softwood or the top of a zamia tree) was covered on the sides by red clay and beeswax and then decorated with parrot, pigeon or cockatoo feathers. This wheel was then rolled down a hill and spears were thrown at it. Men used normal spears and boys used toy spears made from dry grasstree stems (see Roth 1902: 18; Idriess 1980 [1959]; 199–200).[10]

Apart from spear throwers used as clapping sticks, the only other major musical instrument at Bloomfield was a wind instrument called a *yiki-yiki*. Le Souef obtained one at Bloomfield in 1893 and noted that it was:

> a kind of rude musical instrument, a straight hollow trunk of a sapling, 9'6" long by 2 ¾" in diameter at one end and 2" at the other. It is naturally hollow, and not done artificially; it is very seldom that trees for the purpose are found. They blow through it as one would through a fog horn, the noise being made by the blower. It is heard a good way off, and has a musical sound which at distance is very like a flute (Le Souef 1894: 27).

Roth (1902:23–24) also describes the instrument, noting that while not decorated, it often attained a very polished look from heavy use. Instruction in how to play the pipe was given to young men during initiation, but the instrument could be openly played in public.[11]

I have already mentioned some of the materials used in manufacturing the implements for food-processing and other subsistence tasks. Gums and resins were an important resource (samples are in the Australian Museum collection, Kahn 1993: 130–131). I have noted the use of *Canarium australasicum* gum for fixing spear points and axe hafts. *C. muelleri* resin, and the gum from a forest *Causarina* species (probably *C. littoralis*), *Xanthorrhoea johnsonii* and *Grevillea striata* were also widely used. The first two were valuable for trading purposes and thus were not used freely (see below), and the latter two were said not to have very good bonding qualities. On the other hand, the gum extracted from the root of *Erythrophloeum chlorostachys*, the Cooktown ironwood, was readily available and of good quality. The outer sticky covering of the roots was scraped away[12] and gathered together on the end of a stick and then lightly heated on a fire. The substance was then pounded between two stones (which were greased with cassowary fat to avoid sticking), then roasted and pounded again until soft. It was applied to a spear or other implement with a small wooden smoothing board (also greased).

Other manufacturing items included the use of *Ficus opposita* leaves as sandpaper for smoothing spear throwers or any other wooden implement, and candlenut seed oil as a fixer for ochre.

Personal property, decoration, magic, ceremony and conflict

The notion of personal property with respect to material culture items and resources generally was a feature of Kuku–Yalanji culture at Bloomfield. The palm fibre dilly-bags and yam sticks for women and the net-bags, spear throwers and spears for men, were all considered personal items and would not normally be lent to others. The nautilus shell spoons were also very personal

items. A hole was sometimes drilled in them and they were worn around the neck (Roth 1904: 29). Animals were also apparently kept in camp as personal pets. Le Souef (1894: 16) mentions people raising baby scrub fowl; Roth (1902: 9) reports that young boys at Bloomfield had dingo pups as pets while they were being trained for hunting (see also Hodgkinson 1886). Roth states that women sometimes suckled the pups. Idriess (1934: 67); 1980 [1959]: 193) notes that cassowaries, wallabies, turtles and birds were kept as the pets of individuals at Bloomfield.[13]

Dick (MS n.d.) describes a sign system which labelled personal ownership of particular resource items. He states:

> Most simple of... signs are those that denote ownership. A piece of bark knocked from a tree containing a bees' hive; a stick pushed into the mud beside a crab hole; the leaves trimmed from a stick that will eventually become a spear shaft; all will establish such a thing as personal property and will be respected as such even though the one who made the sign may be unknown.

With respect to resources in general, Roth reports an interesting item concerning personal ownership: 'The only instance known to me of women holding what might almost be called real estate is on the Bloomfield, where the patches of zamia plants (edible) are apportioned amongst the females, each woman bequesting her lot to her daughters or other female relatives' (Roth 1906: 9). Unfortunately Kuku–Yalanji informants in the late 1970s could only tentatively confirm this and I have no other evidence of the existence of such a practice.

Decoration of the body was either through the wearing of a physical ornament or through painting or dyeing parts of the body itself. In the first case, there were numerous items worn on the head, the neck, the arms and waist. As I noted above, whole nautilus shells were worn on strings around the neck (men between their shoulders on the back and women between the breasts); Nautilus shell or pearl shell pieces were strung together to make a headband (see Kahn 1993: 116–117)[14] ; necklaces of grass-bugles, 'pencils' of hardened beeswax, shell pieces or seeds of *Abrus precatorius* were worn. The latter seeds were also mixed with beeswax and put onto the hair, as were small clay balls mixed with bloodwood seed pods. During ceremonies and on some hunting trips, prominent Kuku–Yalanji men wore a head ornament consisting of a tuft of cockatoo top-knot feathers stuck into beeswax. The hair itself was modified: it could be cut using the quartz knife; it could be dyed red using the fruit of *Barringtonia racemosa* or rubbed black with charcoal.

On the body, pandanus leaf armlets were worn as well as waist belts or apron-belts (examples are in the Australian Museum collection, Kahn 1993;112–113). Roth (1910c: 39) states: 'The Bloomfield River women wear a circlet of human hair or fibre rope around the waist; it is commonly met with on the older females, and those who have suffered any trouble over a recent accouchement, though in all cases it is looked upon in the light of an ornament, especially when some red colour is woven into it'.

Idriess (1980 [1959]: 243) describes wallaby sinew or plaited hair belts which were worn by men and in which they carried their stone axes. Body painting was done for some hunting trips, and on mourning, fighting, initiation and dancing occasions. Red and yellow ochres, *Grevillea* charcoal and white kaolin clay were the major sources of paint. While men were painted anywhere on their bodies, women were only painted on the faces. More permanent body decorations were obtained through scarification of the chest or arms, or by having the nasal septum pierced. Both of these were done strictly for beautification purposes. In the case of the nose, while the wound was healing, a plug of soft unfertilised banksia stalk was put into the hole and regularly twirled to keep it open. Avulsion of one of the central incisors was also practised at Bloomfield and while this (like nose-piercing) was influenced by prevailing fashion, it was more properly associated with marriage custom (see Anderson 1984).

Decoration of material culture items was minimal. Small zig-zags and other designs were carved into spear throwers to personalise them. The handles of spears were usually painted with red and white stripes, and sections of the dilly bags were sometimes dyed red with the 'bloodroot' tree, *Hoemodorum coccineum.*

At Bloomfield, there were few magic and ceremonial material culture items. Any portion of a human body (deceased or living) could be used for sorcery purposes. Especially common items included tufts of hair, teeth, fingernails, certain bones or 'fat' and these were often carried around in secret wrappings in dilly bags. Other sorcery- and magic-related implements included small quartz-crystal stones (see Kahn 1993:98) and small effigies of people made from softwood which would be burned or placed in a tree. There was also the 'roarer', a piece of wood about

150mm long which was hung from a tree with string to make the area underneath taboo. It was usually painted red with white stripes and often had a small indentation at the bottom. During initiation ceremonies a special hollow log called a *murla* was placed near the site of the ceremony to render the ground taboo. After death some bodies were placed in large bark troughs, very similar to those used domestically, except with a covering over the top. Later in the mourning process, the bones of the deceased were also sometimes carried around by relatives in smaller, pillow-like bark containers.

Kuku–Yalanji fighting spears and the materials used in their manufacture have been listed above. Several other significant material culture items were associated with conflict. Physical conflict at Bloomfield took a number of forms including: (i) generalised fights of one group against another, often in the form of an ambush; (ii) two groups 'squaring off' against each other in a formal fight; (iii) two disputing individuals taking turns to hit each other on the head with sticks; (iv) a formal 'trial by spear' of one individual against a group with a grievance against him. With the first two forms, fighting spears and the curved woomeras were used. In the third case, men used fighting sticks and women used their yam sticks. A fighting stick from Bloomfield River is in the Australian Museum collection (Kahn 1993: 140). There are several eyewitness accounts of women fighting using yam sticks (Le Souef 1897: 26–27; Idriess 1934: 120; 1980 [1959]: 251).[15] In the 'trial' the defendant was given the longer, straight spear thrower and he was allowed to block or deflect the spears thrown at him.

Two other items in this domain were noted by early observers of Kuku–Yalanji culture: the so-called shields and swords. Roth describes the shield:

> The Bloomfield weapon was somewhat more oblong and rectangular as compared with that of the Tully, and usually larger, such dimensions as 3 ½' [106 cm] by 1 ½' [50 cm] being not uncommon, it is however, fast falling into disuse, and even so late as 1898 was only being occasionally manufactured by some of the very old men. The Bloomfield natives called it *kun-juri* and used to paint it with varying designs (Roth 1909: 205).

A shield collected by Roth is in the Australian Museum (Kahn 1993: 141–142). Le Souef also describes a shield 3'8" (110 cm) long by 1'4" (40 cm) wide (Le Souef 1894: 27). Neither source gives any information on methods of manufacture or the woods used at Bloomfield. Both Le Souef and Roth also mention the single-handed sword being found at Bloomfield. This was from 3'3" to 5' (108 cm – 150 cm) long and about 6" (16 cm) wide. Roth (*ibid*) notes that in 1898 only a few old men made this implement. Although older Kuku–Yalanji in the late 1970s knew of these two items and knew that they had been used at Bloomfield, no one had ever made one or seen one for at least 60 years. The swords were sometimes used as fighting sticks during the ritual head-hitting; the shields were given to individuals for blocking spears during the formal trial. There are two swords from Bloomfield in the Australian Museum collection (Kahn 1993: 158–159).

Communications, trade and introduced items

There were two primary ways of sending messages between individuals and groups. The first was the message stick. Only the oldest Kuku–Yalanji in the late 1970s had any recollection of these, and no one was able to say what types of signs and symbols were used on them. They did say that there were two types: one, a special stick for carrying bad news, especially about the death of a relative (*jarrjal*); and the other, an all-purpose stick for general messages (*kaban*).[16] There are several message sticks from Bloomfield in the Australian Museum's Roth collection (Kahn 1993: 126). They were ones given to Roth or to the hospital doctor at Cooktown to inform relatives that a patient was recovering or ones given to Roth to take to Aboriginal people elsewhere to introduce him and ask that they give him this or that item of material culture.

The second method of communication was through signs left on the path or at a site. These were termed *duburan* in Kuku–Yalanji. I have already noted the signs left to denote ownership. Other signs were made of bundles of grass or sticks and placed at about eye-level along the path. These showed who went where, how many people, whether they were armed or not; others showed a turn-off on the path or indicated water or some food resource. As Dick notes, the form these messages took ranged 'from a knotted tussock of grass with the tips pointing in the desired direction, a single stem of grass woven into the branches of a shrub, a number of straws or a palm leaf tied to a tree (all with their butts as pointers), to rather complicated little devices tied to sticks pushed into the ground' (Dick ms.).

McCarthy's (1939) summary of trade in

Aboriginal Australia shows south–east Cape York Peninsula to be an important trade centre, as the source of many trading items such as pearl shell, but also in terms of the amount of trading which occurred within the area (see McCarthy *ibid*: 417–421). As no other data exist on this topic for the Bloomfield area, I shall rely, as McCarthy did, on Roth. Roth stated that in the Bloomfield River district:

> The articles of home production for trade and barter were dilly-bags, spears, woomeras, edible pipe-clay (within recent years), best kind of fighting sticks, shields and swords (in the old days), several varieties of gum-cements, and red ochre. These would be bartered for stingaree-spears, shell ornaments, yellow ochre, edible pipe-clay (in the old days), shields and swords (in recent times)... There were not particular individuals to effect the exchange, each one acting on his own behalf, nor were there any restrictions as to which of their neighbours they might barter with. The principal time of barter was during the laying-season at King's Lake country [King's Plains near the Laura–Cooktown road, C.A], ie. whenever there happened to be a sufficient supply of food to attract them. There was apparently no conception of relative values, and though not a regular practice, members of the same tribe would interchange. (Roth 1910d: 17–18).

Roth also notes that apart from the King's Lake gatherings, Bloomfield district people went up as far as the Laura River district and supplied the Koko–Warra there with red ochre, white clay, and grasstree spears, and received in return, melo shells, reed spear sticks, shell necklaces, stingray spears and fishing nets (string dilly-bags).

The issue of trade raises the matter of the relationship of Kuku–Yalanji material culture with that of other groups in eastern Cape York Peninsula. A detailed consideration is beyond the scope of this paper. However, several points can be made. In many ways, Kuku–Yalanji people had a similar economy to that of other groups living in rainforest environments. This is especially so with respect to the range and type of primary resources. As a consequence, there is commonality of subsistence techniques and of some material culture items (stone-grinding of nuts, leaching techniques, hunting items, etc). On the other hand, it may be misleading to speak of 'rainforest culture', in the sense of a wholly common material culture among the Aboriginal groups who lived in the north Queensland rainforest. In many major domains of material culture Kuku–Yalanji shared more with non-rainforest, coastal and inland peoples to the north and west (at least as far north as Princess Charlotte Bay and to the west over to the middle Palmer River area), than with the 'rainforest people' to the south. This was true of watercraft, of shelter styles and of spears and spear technology. Bloomfield people did not use cane to make baskets, although the closely related groups just to the south near Daintree did. It appears as if the drone-pipe used at Bloomfield came from the Gulf of Carpentaria region via the Laura district Aborigines (Roth 1902: 23). On the other hand, there were certain items at Bloomfield which had no relationship to the material culture of groups either to the north or south.

The most obvious example is the curvilinear lath spear thrower. Roth recounts how one of these washed up on the shore at Cape Bedford north of Cooktown. It was brought to the local missionary, 'who, never having seen one before and being anxious to know something about it, asked the local [Gugu–Yimidhirr] blacks what it was; they could not give it a name, but they told him that the person who made it must have been mad!' (Roth 1901: 199–200).

Further work comparing the material culture of the rainforest groups with those of the groups beyond the boundaries of the rainforest areas (to the north, south and west) is necessary in order to test this hypothesis.

Post-contact material culture change

I will now examine some of the changes which occurred in Kuku–Yalanji material culture in the first few decades after first contact, and then move to a brief description of it during the late 1970s.

The earliest contact items of interest for Kuku–Yalanji were primarily metal, glass and cloth. Iron was found at Bloomfield six years before any European settlers arrived. In 1873, William Hann, the first land explorer in south-east Cape York Peninsula, met a group of Aborigines at Bloomfield carrying 'iron tomahawks' (Hann 1873: 16). Later Hann found in a camp at Bloomfield 'pieces of iron, and amongst them a rod of the same metal, about three feet in length, evidently used as a yam stick' (Hann *ibid*: 20). On one occasion, during the night Aborigines on the upper Daintree stole a digging pick, a washpan and 'items for mending clothes' from Hann's supplies. The first Lutheran missionaries at Bloomfield in 1886 had constant difficulties with the Aborigines taking metal tools (Meyer 1891). Roth reports finding iron as part of many domestic implements at Bloomfield: iron wedged into a

wooden handle to make an adze for scraping out canoes (Roth 1904: 22; one of these from Bloomfield is in the Australian Museum, Kahn 1993: 133); a piece of iron or a table knife cemented into the end of a digging stick (*ibid.*: 24); the use of glass instead of quartz in fighting spears (Roth 1909: 193); the use of iron (for example, three-cornered files) for barbed turtle harpoons (Roth 1909: 76; 1904: 32).[17] Several knives from Bloomfield made from shovel heads are held by the Queensland Museum. Metal fishhooks rapidly replaced the shell ones, and wire (particularly fencing wire) quickly took the place of wooden points for spear ends. Eleven out of sixteen spears donated in 1903 by Roth to the Queensland Museum from Bloomfield had iron heads or barbs. Steel axes were valued items at Bloomfield and a number of observers note the willingness of Kuku–Yalanji men to undertake any amount of work for a European settler in return for these tools (see, for example Idriess 1980 [1959]: 243). Roth (1898a) notes that blankets being given out by the police for Aborigines at Bloomfield were being used as sails for the canoes. Hershberger and Hershberger (1982 *pers. comm.*) saw a traditional canoe at Bloomfield in the early 1960s; generally though, wooden dinghies had replaced the outrigger canoe by the Second World War.

Kuku–Yalanji material culture in the late 1970s

A comprehensive description of Kuku–Yalanji material culture in the 1970s is not within the scope of this paper. Here I will merely give a few examples to demonstrate some of the continuities in knowledge and usage of items as well as some of the changes. The use of the bush by Kuku–Yalanji during the period 1977–1980 was an integral part of the mission economy (see Anderson 1982), and the following observations are restricted to material culture items relating to this 'bush component'.

Bush-food resources important during this time were fish, shellfish, pig, turtle and cassowary meat, wild fruits, hairy yam and the introduced 'New Guinea yam'. Spears were used for many species of fish, especially mullet. These spears were multi-pronged with fencing or other wire. Commercial string was used to bind the prongs, and this was covered with some combination of ironwood resin, car battery 'tar', 'Araldite' (store-bought glue), or asphalt tar. The handles were the same as in earlier days, as were the spear throwers. Some substitutions in manufacturing technology for spears were apparent—for example, use of steel knives and use of margarine or butter instead of cassowary fat for greasing. Turtle hunting was done from boats with outboard motors, and while the harpoon handle was the same as in pre-contact times, European rope and steel harpoon points were used. Diving for freshwater eelfish and turtles in inland areas was done using diving goggles and a flexible steel rod. For land hunting .22 rifles were almost exclusively used.[18] The stone ovens were often used for cooking meat in the bush camps I stayed in during my fieldwork. Traditional bark troughs and fire tongs of lawyer cane were also relied upon.

Fishing (without spears) was done with plastic hand reels and lines, metal fish hooks with no sinkers or floats. Bush vegetables were dug using mainly steel digging sticks, often a shortened and sharpened crowbar. Processing of *Dioscorea sativa* occurred on a number of occasions. Empty metal flour drums were used for boiling the yams; plastic buckets were used for separation of the yam mixture from the toxin; but the palm-fibre dilly bags were still used for the initial mashing. Only three or four women were able still to make the dilly bags in 1982 at Bloomfield. Metal billy cans made from old powdered milk tins were very common; machetes, metal files, shovels and steel axes were also in the bush camps. Plastic tarpaulins were normally laid on a bush frame, although knowledge of the old hut-type bush shelter was general amongst adults. Transport from the mission to bush camps was primarily by boat, but also by horse and truck.

Personal clothing styles for males at Bloomfield were heavily influenced by 'cowboy' or stockman style. Men wore riding boots for special occasions; western shirts and hats were common at all times. Elastic bandages were sometimes worn by young men on the arms and wrists in an exact parallel with the use of pandanus leaf bands. Both were thought to bring good luck and to demonstrate strength in fighting. Items used for sorcery purposes were mostly along traditional lines. New things which were used by men for 'love magic' included hair oil, scent and women's hankies. These were often mixed with traditional bush substances.

Older-style ceremonies were normally only held for fun or in association with funerals. At these, traditional south-eastern Cape York Peninsula dances and songs were performed with spear throwers used as clapping sticks. No body decoration was done for the dances but men

normally stripped to only shorts or trousers for dancing. Some 'Island style' (Melanesian) singing was occasionally done with empty flour tins used as drums with guitar accompaniment. In the mission generally, country and western music was the most popular form, with several people having guitars and an accordion for concerts of this music.

Sources

Sources of data for this paper have been both anthropological and historical. I conducted fieldwork of approximately fourteen months at Bloomfield River between 1977 and 1980, and a further month in 1982. Numerous other trips have occurred since then. Part of this work has involved reconstructing a picture of Kuku–Yalanji life prior to significant European activity in the Bloomfield region. Publications arising from this work with data relevant to the present paper include Anderson (1980; 1982; 1983; 1984). Very little earlier anthropological work exists. I have cited above the relevant works of W. E. Roth, Northern Protector of Aboriginals in Cooktown from 1897 to 1905. McConnel (1931; 1939–1940) describes aspects of Kuku–Yalanji mythology and social organisation. Fortunately, several careful European observers lived in and visited the Bloomfield area in the late nineteenth century and early twentieth century. They accurately recorded a great deal of data on Kuku–Yalanji culture. D. Le Souef was a naturalist who visited Bloomfield several times in the 1890s and as I noted above, the author Ion Idriess lived at Bloomfield for some time before the First World War. I have almost always been able to confirm the accuracy of their data from other sources. Roth and W.O. Hodgkinson, the Police Magistrate at Cooktown in 1886, both had access to European settlers at Bloomfield—Robert Hislop and Louis Bauer—both of whom were fluent in Kuku–Yalanji and had a deep understanding of Kuku–Yalanji culture.

Collections which contain Bloomfield River material culture items include the Roth Collections of the Queensland Museum in Brisbane and the Australian Museum in Sydney (see Kahn 1993). H. and R. Hershberger, linguists with the Summer Institute of Linguistics, lived and worked at Bloomfield from the early 1960s until the 1980s and have a good representative collection of Kuku–Yalanji items.

Acknowledgments

My fieldwork was supported by the Australian Institute of Aboriginal and Torres Strait Islander Studies and the Department of Anthropology and Sociology, University of Queensland. For help in gaining the information on which this paper is based I wish particularly to thank at Bloomfield: the late John Walker, Bob Yerrie, Mabel Webb, the late John Mossman, Hank and Ruth Hershberger and Harry Dick. In Brisbane and on a field trip to Bloomfield in 1982, Richard Robins, of the Queensland Museum, aided with aspects of this study. I am also grateful to Philip Jones and Peter Sutton for their useful comments.

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Endnotes

[1] Because this paper is a reconstruction, I generally use the past tense. This is not to imply that some of the practices or material culture items are not still part of contemporary Kuku–Yalanji life. In general, I try to specify the date for a particular observation. As noted in the section, 'Sources', I have relied on a mixture of archival and oral sources for this paper. In addition, active learning and participation in bush activities has also been an important source of information. Although, some might think of such papers as old-fashioned, I am happy that this work can be a medium for transmission of knowledge from past generations to the young Kuku–Yalanji people of today.

[2] The earliest historical sources describe Kuku–Yalanji camps in just these locations (see King 1827; Le Souef 1896; Roth 1898a; Meek 1913, Rowan 1912).

[3] Very few examples of these stone axes have been found in south-east Cape York Peninsula. Roth (1901a: 8) offered the explanation that in this area, 'the old discarded stone heads of the original axes have been utilised in large measure for lining the ground-ovens, a fact which will account in large measure for the paucity in this district of remains of these implements at the present day'.

[4] King also commented on this. On both of his visits to Bloomfield, he and his men found what he termed 'huts' on the river bank and on the beaches. On his second trip in 1821 he noted that on the beach they 'found some natives' huts; some of which were of more substantial construction than usual' (King 1827, Vol.2: 14).

[5] A set of these fire-sticks is in the Roth Collection at the Australian Museum (Kahn 1993: 118–119).

[6] Roth was given this description by Mr. Robert Hislop, a European settler at Bloomfield whose property at Wyalla Plains contained one of the cycad-processing sites.

[7] A Kuku–Nyungkul speaking man from the Annan River told me in 1977 that these dilly bags were also occasionally used as nets and were dragged through small lagoons, at least at Kings Plains just to the north of the Annan River area. Other than this, Bloomfield Kuku–Yalanji had no knowledge of nets being used (see Kahn 1993: 137–139).

[8] This description was mostly obtained by watching Kuku–Yalanji women prepare this yam in 1978. I have also discussed with people the changes which have occurred in the process (e.g. the yams were boiled instead of roasted when I observed the process). Roth (1901a: 11–12) includes a description very similar to mine.

[9] These stone ovens, termed *kurrma*, were still extensively used at Bloomfield in the 1980s, primarily for pig, eelfish and marine turtle. See Idriess (1980 [1959]: 255); and Roth (1901a: 8) for similar descriptions.

[10] Roth (1902) includes a photograph of some young Aboriginal men at Cape Bedford Mission north of Cooktown playing this game.

[11] It is reported that one of the reasons for the relatively short lifespan of the *yiki-yiki* was that older men smashed them after growing weary of young men playing them for hours on end. Both Roth (1902: 24) and Idriess (1934: 67); 1980 [1959]: 199) mention this. An example of these 'trumpets' is in the Australian Museum collection (Kahn 1993: 127).

[12] Roth (1904: 12) states that at Bloomfield, before the underground piece was cut away, it would be tested by rubbing a firestick onto it, getting portions of the sticky covering to melt off, and trying them between the closed teeth—if sticky there, the gum would be suitable for use and further pieces removed.

[13] Tindale (1974: 109) also reports that young cassowaries were tethered and reared by north Queensland rainforest Aborigines until fat enough to eat. For Bloomfield, though, the observers I have mentioned all noted that the pets were never fed enough to live for long in camp.

[14] Roth (1910c: *passim*) notes that shell ornaments went through distinct fads and fashions in coastal Cape York Peninsula.

[15] As a punishment for certain minor transgressions, people were also struck on the head with a spear thrower by an older man.

[16] In the late 1970s this was the word used in Kuku–Yalanji for letters or for any written messages.

[17] The ability to make strong barbed harpoons must have had a dramatic effect on the success of turtle expeditions. Roth (1909: 76) notes: '[t]he dependency of the turtle [hunting] upon iron (which is capable of piercing the carapace) was explained to me by the young men [of the Pennefather River] by reason of the fact that while wooden harpoons were in vogue these creatures could only be caught by striking them in the soft parts; ie., the neck and posteriorly, and their capture was consequently no easy matter'.

[18] Although the word *marrkin* was used in 1980 for 'rifle' (a word used throughout much of Cape York), the older word is *mirrba*. This is another name for the spear thrower used at Bloomfield during the formal 'trial by spear'.

A SPECIMEN OF GIANT SQUID, *ARCHITEUTHIS* SP., FROM SOUTH AUSTRALIAN WATERS

W. ZEIDLER & K. L. GOWLETT-HOLMES

ZEIDLER, W. & GOWLETT-HOLMES, K. L. 1996. A specimen of giant squid, *Architeuthis* sp., from South Australian waters. *Records of the South Australian Museum* **29**(1): 85–91.

This is the first record of *Architeuthis* from South Australian waters. The specimen was found floating off Cape Banks near Mount Gambier. The condition of the specimen indicated that it was only recently dead. Tissue samples were taken and are available for biochemical analysis. Illustrations of the specimen are provided together with details of meristic characters. The specimen, a female, had a dorsal mantle the length of 1.53 m, a head length of 0.32 m; the tentacle which had become detached, measured 7.39 m, and altogether it weighed 86 kg.

W. Zeidler and K. L. Gowlett-Holmes, Department of Marine Invertebrates, South Australian Museum, North Terrace, Adelaide, South Australia 5000. Manuscript received 30 August 1995.

Specimens of *Architeuthis* have been recorded from most of the world's oceans, most frequently from Newfoundland, Northern Europe, Japan, South Africa and New Zealand (Aldrich 1991; Clarke 1966, 1980; Clarke & MacLeod 1982; Roper & Boss 1982). Most of these recent records are those of strandings or from the stomachs of sperm whales. More recently, specimens have been caught by deep-sea trawls (e.g. Jackson *et. al.* 1991) and only in January this year a specimen slightly larger than the South Australian one was caught off King Island, Bass Strait and an even larger one was caught 500 km off the South Island of New Zealand.

In Australia there have been occasional, but usually unconfirmed, reports of large squid floating off the southern Australian coast. Some of these are probably of *Taningia danae* (Zeidler 1981) while others most likely represent *Architeuthis*, as confirmed by this report.

The first record of *Architeuthis* from Australian waters is by Allan (1948) who recorded a specimen which was washed ashore at Wingan Inlet, Victoria in mid-September, 1948. It had a mantle length of 2.3 m. The specimen was considerably mutilated with the tentacles missing and the internal organs and gladius had been removed. Only 'the head with arms, and tail with fins, were preserved for future reference'.

Another two specimens were obtained from the stomachs of sperm whales caught by the Cheynes Beach Whaling Company, Albany, Western Australia, in late 1978 (Anon. 1980). The largest specimen weighed 280 kg and was used in promotional displays; its current whereabouts is unknown. The second, much smaller, specimen is preserved at the Wallaroo Heritage and Nautical Museum, South Australia. Clarke (1980) also recorded the beaks and flesh of *Architeuthis* from the stomachs of sperm whales caught near Albany.

The only other, previous, records of *Architeuthis* from Australian waters (apart from the one caught in January this year) are that of a larval specimen (mantle length 10.3 mm) caught in the Tasman Sea, 33°19.4'S 155°00.3'E, at a depth of 20 m (Lu 1986) and a female (mantle length 42.2 cm) from the same area, 33°44'S, 153°00'E, taken in a oblique trawl from the surface to a depth of 600 m (Jackson *et. al.* 1991).

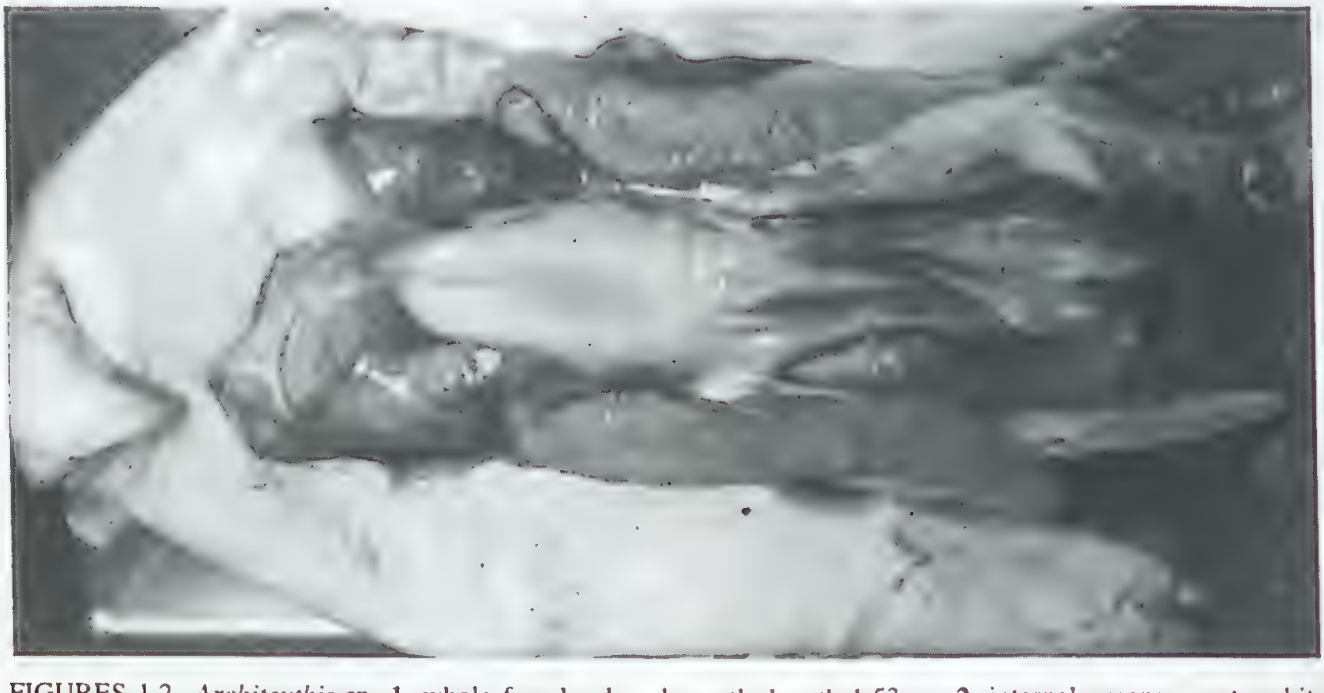
The specimen which is the subject of this report (Fig. 1) was found floating on the surface, recently dead, about 3.2 nautical miles SSE of Cape Banks (37°56.32'S 140°20.79'E) over a bottom depth of about 25 m. It was found by Mr. M. Von Stanke on FV 'Ocean Lady' on 9 March, 1995 and is now preserved in the South Australian Museum (SAM D18936).

The relatively good condition of the present specimen is significant because live specimens are rarely captured and most stranded specimens are partly decomposed and incomplete as are specimens from whale stomachs. It was immediately stored on ice and transported to the Museum the next day without being frozen.

Tissue samples were taken from the digestive gland and from one of the arms and frozen in liquid nitrogen before being stored in a deep freeze at −80° C. Samples of muscle were also

1

2



FIGURES 1,2. *Architeuthis* sp. **1**, whole female, dorsal mantle length 1.53 m; **2**, internal organs – note white bilobed midamental glands between gills.

TABLE 1. *Architeuthis* sp. (SAM D18936) meristic characters

Character	Measurement (mm)
Body	
Mantle length (dorsal)	1 530
Mantle length (ventral)	1 400
Mantle width (flattened)	440
Mantle thickness (max.)	40
Fin length including 'tail' (damaged)	430
Fin width (right) to edge of mantle (ventral view)	175
Funnel length	250
Funnel width across opening	110
Locking cartilage, length	190
Locking cartilage, width (max.)	50
Gladius length	1 440
Gladius width (max.)	190
Rachis length	340
Rachis width (max.)	130
Head (detached)	
Length	320
Width	270
Eye orbit diameter (eyes missing)	170
Distance between eye orbits (dorsally)	90
Radula length (curled)	70
Radula width (between teeth, max.)	10
Arms (all damaged with most tips missing)	
Left I	810
Left II	1 450
Left III	1 330
Left IV	1 140
Right I	610
Right II	1 120
Right III	1 290
Right IV	1 750
Sucker diam., largest from left I	14
Sucker diam., smallest from left I	7
Tentacles	
Left (club etc. missing)	4 260
Right (club detached)	2 970
Right total	7 390
Club and part of tentacle	4 420
Dactylus	195
Manus	410
Carpus	130
Width of club (max.)	50
Club sucker – largest diameter	25

taken from the mantle and tentacle and preserved in 100% alcohol. Both the frozen (SAM B80) and alcohol-fixed (SAM XD0040) samples are available for biochemical analysis.

We have not provided details of the internal anatomy (Fig. 2) as this is beyond our expertise but in Table 1 we provide details of meristic characters following Roper and Voss (1983). All measurements were made prior to preservation. The body weighed 48 kg and the head with arms and tentacles weighed 38 kg.

The tips of all the arms were missing, or severely damaged, so it was not possible to determine the sex externally. On dissection the specimen proved to be a female with the gonad full of small white eggs.

The gladius was removed and preserved separately. It was relatively fragmented and the illustration (Fig. 3) was produced by tracing the outline of pieces as they were removed. Dimensions are given in Table 1.

The beaks (Fig. 4) and radula (Fig. 5) were also removed and preserved separately. The dimensions of the beaks (Table 2) are according to Wolff (1984). The radula is like that illustrated by Roper and Boss (1982), each row consists of 7 teeth with marginal plates, cental tooth tricuspid, central cusp twice as long as outer cusp; first lateral teeth bicuspid, inner cusp twice as long as outer cusp; second and third lateral teeth with large, single cusps, horn-like; marginal plate reduced to small knob. The first 17 rows show little wear and breakage, but the next 26 rows show moderate to severe wear, with the cusps on the central teeth, and to a lesser extent on the first

TABLE 2. *Architeuthis* sp. (SAM D18936) beak dimensions

Character	Measurement (mm)
Upper beak	
Hood length	75
Rostral length	18
Wing width	22
Rostral tip to inner margin of wing	37
Wing to crest length	94
Crest length	107
Crest depth (central)	45
Jaw angle width	15
Lower beak	
Rostral tip to inner posterior corner of lateral wall	74
Rostral length	18
Rostral tip to inner margin of wing	63
Wing length	52
Jaw angle width	15
Crest depth (central)	32

FIGURE 3. *Architeuthis* sp. Illustration of the gladius, 1.44 m length. Scale = 50cm.

lateral teeth, being completely worn away in many rows. The remaining rows are teeth still forming or not yet in use.

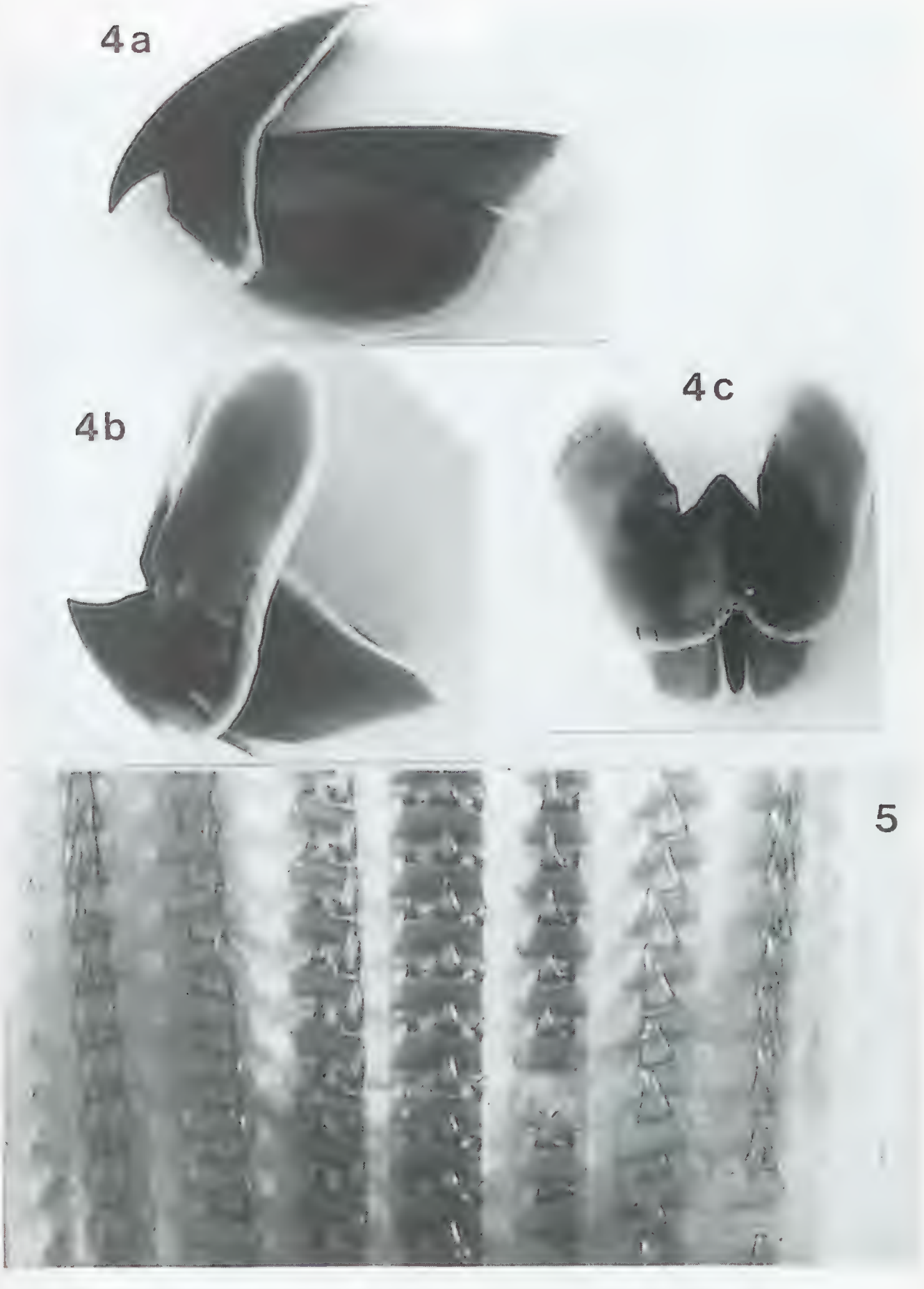
Only one of the tentacles with the club end (Figs 6 & 7) was present when the specimen was collected and that became detached when the specimen was retrieved from the ocean. It is the right tentacle which combined with the remnant section on the head measured 7.39 m.

The stomach contained nine squid suckers and the remains of others, but was otherwise empty. The suckers are without the sucker rings so it is impossible to determine the taxon from which they came with certainty other than that they came from a relatively large species; the suckers ranging in size from 13 mm to 16 mm in diameter. According to Roper and Boss (1982) most specimens collected have empty stomachs as active, well-fed, animals are unlikely to become stranded and even if something was to be found in the stomach it would be difficult to identify because the radula and beak shred prey into small pieces and the digestive enzymes work rapidly. Nevertheless *Architeuthis* seems to feed on small fish and large invertebrates such as other cephalopods which is supported, in part, by the present findings.

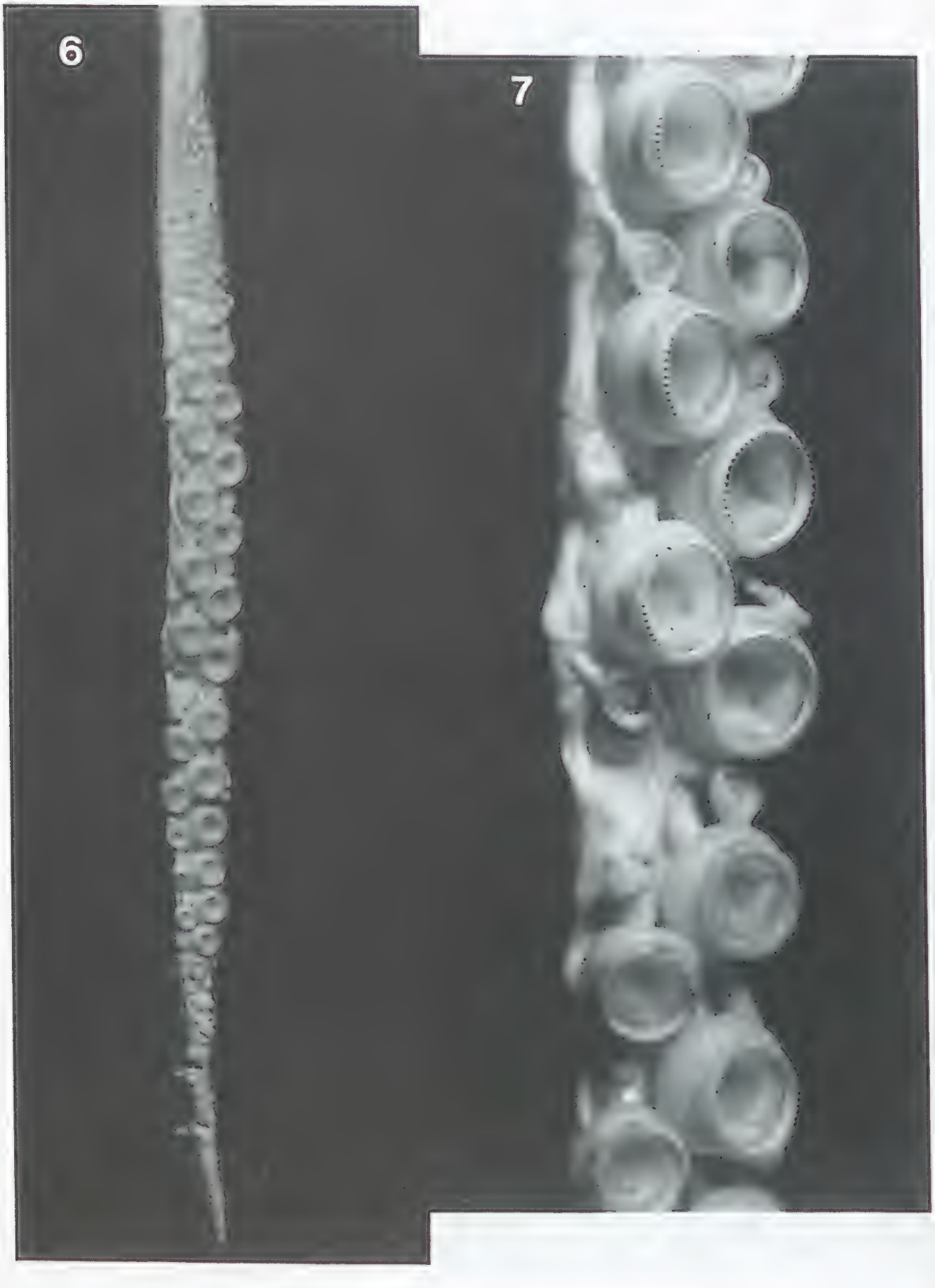
Virtually nothing is known about *Architeuthis* in Australian waters. The present specimen had two large gashes (approx. 20 cm) through the left side of the mantle, suggesting that it may have been attacked by a predator such as a sperm whale although no whales were reported in the region at the time. The specimen was in extremely good condition indicating that it was only recently dead and although it was found floating relatively close to the shore in water of only 25 m depth the Continental Shelf drops off rapidy along that part of the coast to a depth of 1100 m within 20 nautical miles. More information on the biology of these animals is given by Clarke (1966, 1980) and Aldrich (1991) and information on juvenile stages is provided by Roper and Young (1972), Roper and Boss (1992) and Roper (1992).

Acknowledgments

We are most grateful to Mr Martin Von Stanke, Carpenter Rocks, South Australia for collecting the specimen of *Architeuthis* and for donating it to the South Australian Museum. Mr Thierry Laperousaz, South Australian Museum, is thanked for helping to transport the specimen to the Museum. Ms Jan Forrest, South



FIGURES 4,5. *Architeuthis* sp. **4**a, upper beak; 4b,c, lower beak; **5**, part of radula from sac, not worn.



FIGURES 6,7. *Architeuthis* sp. Right tentacular club and enlargement of manus illustrating suckers.

Australian Museum, is gratefully acknowledged for all of the photographs (except Fig. 1). An anonymous referee and Dr C. F. E. Roper, Smithsonian Institution, Washington D.C., provided many useful comments which much improved the manuscript. Mrs Vicki Wade and Robyn Cherrington typed the manuscript.

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A NOTE ON TWO SIPUNCULANS (SIPUNCULA) AND AN ECHIURAN (ECHIURA) FROM PRYDZ BAY, ANTARCTICA

Several sipunculans and an echiuran were collected in the region of Prydz Bay (between the Australian bases of Davis and Mawson) during the summer of 1991 by one of us (WZ) and K. Gowlett-Holmes of the South Australian Museum while on board Australia's ice breaker 'Aurora Australis' during a Marine Science voyage organised by ANARE (Australian National Antarctic Research Expeditions). Although the species have been reported previously from the Falkland Islands, Graham Land, Ross Sea and Commonwealth Bay the present findings on the opposite side of the continent confirm that their distribution is circum-polar.

Specimens were obtained from the by-catch of exploratory fishing trawls using an International Young Gadoid Pelagic Trawl (IYGPT) net and preserved in 2% formaldehyde/propylene glycol solution; later transferred to 75% alcohol. The specimens are deposited in the South Australian Museum (SAM).

Material was collected from the following stations as designated by ANARE:

Stn. 24B; 67°30.87'S, 73°33.68'E to 67°29.20'S, 73°31.04'E; 576–581 m; 25 Jan. 1991.

Stn. 77; 67°57.95'S, 76°20.58'E to 67°56.36'S, 76°23.51'E; 441–436 m; 19 Feb. 1991.

Stn. 78; 68°27.91'S, 75°26.60'E to 68°26.11'S, 75°24.33'E; 622–616 m; 19 Feb. 1991.

Stn. 79; 68°58.33'S, 74°23.84'E to 68°56.48'S, 74°24.33'E; 787 m; 19 Feb. 1991.

Stn. 84; 68°03.77'S, 73°09.33'E to 68°02.66'S, 73°12.60'E; 683–680 m; 21 Feb. 1991.

Stn. 90; 67°00.25'S, 72°40.21'E to 66°58.53'S, 72°36.91'E; 536–532 m; 24 Feb. 1991.

SIPUNCULA

Golfingia margaritacea margaritacea (Sars, 1851)

Sipunculus margaritaceus Sars, 1851: 196–197

Synonymy – see Cutler (1994: 71–72)

Material examined (no. of specimens in brackets)

Stn. 77, SAM E1164 (2); Stn 78, SAM E1174 (1); Stn. 84, SAM E1173 (10); Stn. 90, SAM E1175 (1).

Description

Specimens large, stout, cylindrical or sausage-shaped. Trunk of two largest 95–105 mm, maximum width 25–30 mm. Posterior extremity rounded. Body wall thick, covered with very small white papillae. Longitudinal musculature continuous. Introvert much more slender than trunk, not fully everted in any specimen, estimated length in largest specimen 40 mm; no spines or hooks. Two pairs of retractor muscles arising at different levels from anterior half of trunk. Two fastening muscles; spindle muscle not fixed posteriorly. Numerous (up to 22) tightly wound, double, intestinal coils. Wing muscle present. Caecum in one dissected specimen but not in a second. Contractile vessel simple. Two free nephridia.

Remarks

On comparing specimens there is no doubt that those from Prydz Bay are conspecific with those from the Ross Sea, described by Edmonds (1965) as *G. margaritacea capsiformis*. The synonymies given by Stephen and Edmonds (1972: 94) and Cutler and Cutler (1987: 743), however, show that *G. margaritacea* and its subspecies are amongst the most commonly reported sipunculans and that the differences between the subspecies are often of doubtful significance and taxonomic importance. On morphological grounds Cutler and Cutler (1987) consider that the best name for most of the reported subspecies to be *G. margaritacea margaritacea*. Their conclusions have been accepted in the present paper.

Distribution

Golfingia margaritacea margaritacea is circum-polar at the Antarctic. A number of previous workers (listed in Edmonds 1965) consider it to be bi-polar also. Cutler & Cutler (1987) state that '*G. margaritacea margaritacea* is a widely distributed taxon, living in all sections of the Atlantic, Arctic and Antarctic Oceans, the North-, South-east and South-west Pacific...'

Golfingia anderssoni (Théel, 1911)

Phascolosoma anderssoni Théel, 1911: 28–29

Golfingia anderssoni – Edmonds 1965: 30–31

Material Examined

Stn. 24B, SAM E1629 (1); Stn. 84, SAM E1628 (6)

Description

Specimens long, cylindrical but most twisted and damaged. Best specimen possesses a thin, tapering caudal appendage 12 mm long covered with small papillae but posterior 20 mm of trunk bears prominent, swollen, bladder-like papillae. Maximum length of trunk from tip of caudal appendage to base of introvert 175 mm, maximum width (posteriorly) 9 mm. Introvert slender, about 140 mm long, anterior tip missing. Longitudinal musculature continuous. Four retractor muscles, a stout ventral pair and a more slender dorsal pair, the latter arising more anteriorly than former. No introvert hooks or spines. Contractile vessel simple. Two tubular, free nephridia.

Remarks

Although the specimens were damaged, the presence of four retractor muscles, a caudal appendage and prominent, swollen papillae on the posterior region of the trunk enables them to be identified as *G. anderssoni.*

Distribution

Most common in Antarctic and sub-Antarctic waters, including Graham Land, South Georgia, Ross Sea and now Prydz Bay. Circum-polar.

ECHIURA

Echiurus sp.

Material examined (no. of specimens in brackets)

Stn. 79, SAM E1630 (2); Stn. 84, SAM E1631 (2).

Description

Specimens badly damaged, lacking a proboscis and internal organs. The identification as *Echiurus* is based on the presence of two ventral setae anteriorly, two imperfect circles of large setae surrounding the posteriorly placed anus and some circles of large papillae ringing the anterior of the trunk. No other details can be given with certainty.

Remarks

Echiurus antarcticus Spengel, 1912 has been reported from Chile (Wesenberg-Lund 1955) and South Georgia (Spengel 1912; Stephen 1941).

Acknowledgments

We are indebted to the captain Roger Russling, and the crew of the RSV 'Aurora Australis' for making the collection of material possible. Dick Williams, the voyage leader, is thanked for providing ready access to the bycatch and for his leadership. All costs while on board ship and in Antarctica were met by ANARE, other funds for this work were provided by the South Australian Museum.

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REVISION OF THE LARVAE OF *PARATROMBIUM* (ACARINA: TROMBIDIIDAE) OF AUSTRALIA AND PAPUA NEW GUINEA, WITH NOTES ON LIFE HISTORIES

R. V. SOUTHCOTT

SOUTHCOTT, R. V. 1997. Revision of the larvae of *Paratrombium* of Australia and Papua New Guinea, with notes on life histories. *Records of the South Australian Museum* **29**(2): 95–120.

The larvae of *Paratrombium* Bruyant, 1910 (Acarina: Trombidiidae) of Australia and Papua New Guinea are described, from four new species: *P. australe*, sp. nov. and *P. lindsayi*, sp. nov. from southern Australia, *P. curculionis*, sp. nov. from northern Queensland, and *P. anemone*, sp. nov. from Papua New Guinea. The larvae of *P. australe* and *P. lindsayi* are correlated with adults by experimental rearing, with description of the ovum and prelarva, and attempts to find suitable larval hosts; these larvae experimentally parasitized small Diptera and Hymenoptera, and a species of Mantispidae (Neuroptera). The adults of *P. australe* and *P. lindsayi* are compared with previously described Australian adults of *Paratrombium*. Nomenclatural changes for previously described Australian adults of *Paratrombium* are proposed.

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Paratrombium Bruyant, 1910 was founded for a larval European mite, *P. egregium* Bruyant, 1910. Although its original author recognized its trombidioid affinities, and (1912) recorded it as a parasite of *Pompilus pectinipes* Lind. (Hymenoptera), the genus was not correlated with its post-larval instar until Feider (1952), in Europe, reared larvae from ova laid by the adult *P. divisipili* (Feider, 1950). Newell (1958) described as new two North American species, *P. bidactylus* Newell, 1958 and *P. quadriseta* Newell, 1958, which he had successfully reared from adults. Robaux (1969), in Europe, successfully reared and described larvae from an adult he identified as *P. megalochirum* (Berlese, 1910). Earlier, an uncorrelated species, *P. meruense* (Trägårdh, 1908), had been described from eastern Africa; it was redescribed by Oudemans (1912).

While the larval *Paratrombium* is well characterized and easily recognized (e. g. by being the only known trombidioid larva with a pectinate medial coxala I), the same does not apply with the adults. Hirst (1928a,b 1929) placed some Australian adults of *Paratrombium* in *Microtrombidium* Haller, 1882 and *Dinothrombium* Oudemans, 1910, and Womersley (1934) also placed some adults in *Caenothrombium* Oudemans, 1927. Among adult forms was *Caenothrombium miniatum* Womersley, 1934, for which Southcott (1986) erected *Pollicotrombium* Southcott, 1986.

In this paper four new species of *Paratrombium* are described from larvae, three from Australia and one from Papua New Guinea. The two southern Australian species, *P. australe* sp. nov. and *P. lindsayi* sp. nov., have been successfully reared from adults, and their adult and other instars are also described.

Materials And Methods

Adults and larvae of trombidioid mites have been collected by the author over many years, either free-living, or by extraction of samples of soil and litter with the Berlese funnel. Initial Berlese funnel extractions were into 70% ethanol; later ones were extracted free-living, for biological observation. Most collecting was done in eucalypt forests in the Mt Lofty Ranges, South Australia. A few specimens were forwarded from other collectors.

Adults used in possible rearing experiments were placed in small glass tubes, with a small amount of damp soil or bark from the collection locality; tubes were closed with well-fitting corks, with a face free from cracks, after being trimmed with a razor.

Some batches of eggs collected in the field were confined similarly, and some of these hatched into larvae. Adults died soon after oviposition and decomposed, with some mould development and

some degree of limb disarticulation; they were mounted through standard water-soluble media (initially Berlese's gum chloral medium, then polyvinyl alcohol media, and finally Hoyer's gum chloral medium). Most disarticulation of adults was mild; where severe, leg segments were recognized by shape and measurements.

Larvae swarming in the tubes were found to be positively phototropic, allowing small numbers to transfer into other tubes for experiments to find possible insect hosts for them to parasitize.

Microscopy was by Leitz Ortholux/Laborlux microscope with phase-contrast and polarizing facilities. All drawings were made with the aid of a drawing apparatus.

Seta and other anatomical terminology follows Southcott (1992, 1993, 1994).

All measurements are in micrometres (μm) unless otherwise specified.

Abbreviations are as follows: SAM = South Australian Museum, Adelaide; RVS = R. V. Southcott

Systematics

Family TROMBIDIIDAE Leach

Subfamily TROMBIDIINAE Leach

Trombidiidae Leach, 1815: 395 (as Trombidides)

Trombidiinae Southcott, 1986: 8

For additional synonymy see Southcott 1986: 8

Type genus *Trombidium* Fabricius, 1775.

Genus ***Paratrombium*** Bruyant

Paratrombium Bruyant, 1910: 347; Southcott 1986: 43.

For additional synonymy see Southcott 1986: 43.

Type species: *Paratrombium egregium* Bruyant, 1910.

Definition of larva: as in Southcott 1986: 43, and additionally: supracoxala present on gnathosoma and on leg I.

Definition of adult: as in Southcott 1986: 43.

Key To The Larvae Of *Paratrombium* Of The World

1. Posterior dorsal scutum with four setae .... *P. quadriseta* Newell, 1958
— Posterior dorsal scutum with two setae 2
2 (1). Posterior claw of tarsus III not reduced ... 3
— Posterior claw of tarsus III reduced 7
3 (2). AM setae stout, tusk-like 4
— AM setae not stout, tusk-like 5
4 (3). MA/AP 1.43–1.82. Medial coxala I with 15–20 digitations ..... *P. australe* sp. nov.
— MA/AP 1.84–2.29. Medial coxala I with *c.* 27 digitations .....*P. lindsayi* sp. nov.
5 (3). Medial coxala I with about 17 digitations. Tritorostral setae expanded, with several blunted digitations ..... *P. anemone* sp. nov.
— Medial coxala I with less than 17 digitations. Tritorostral setae not or little expanded, with numerous fine, pointed setules 6
6 (5). L> 200μm. SB > 150μm. Medial coxala I with 9 digitations .... *P. meruense* (Trägårdh, 1908)
— L< 200μm. SB < 150μm. Medial coxala I with 12–13 digitations .... *P. curculionis* sp. nov.
7 (2). Tritorostral setae of gnathosoma slender, tapering throughout..... ..... *P. bidactylus* Newell, 1958
— Tritorostral setae of gnathosoma not slender and tapering 8
8 (7). Medial coxala I with 14–16 digitations .... *P. megalochirum* (Berlese, 1910)
— Medial coxala I with less than 13 digitations 9
9 (8). Tritorostral setae moderately thickened in their central part, with a heavy coating of short setules; setae of posterior dorsal scutum placed before middle of scutum; SB < PW ..... *P. egregium* Bruyant, 1910
— Tritorostral setae apparently considerably thickened with long setules, so that they appear markedly enlarged in their distal half; setae of posterior dorsal scutum placed behind middle of scutum. SB not < PW ..... *P. divisipili* (Feider, 1950)

* This criterion is assumed to be the case with *P. meruense*; according to Oudemans (1912: 97) the holotype larva (the sole specimen) lacked the gnathosoma.

Paratrombium australe sp. nov.
(Figs 1A, B, 2A–D, 3, 4A–G)

Material examined

Holotype. South Australia. Myponga, reared larva ACB294L3, reared 29.xi.1947, from ova laid by adult ACB294A, R.V. Southcott. SAM.

Paratypes. South Australia. Myponga, 12.x.1947, adult female ACB294A, also reared larvae ACB294L1–2, 5–8 (see details under Biology). Workanda Creek, National Park, Belair, 27.x.1951, many ova, from which larvae emerged, R.V.S., ACB546 (see under Biology). Adult ACB585A, with idiosoma length 2130, width 1260, 30.viii.1953, RVS, which laid ova which produced many larvae, including ACB585L1–12 (see Biology). SAM.

Diagnosis of larva

Posterior dorsal scutum with two setae. Posterior claw of tarsus III not reduced. AM setae thickened, pointed, tusk-like. Medial coxala I with 15–20 digitations. Odontus strongly curved, diverging into two well-separated tines. Tritorostral setae curved, pointed, with a brush of fine setules in distal 2/3. MA/AP 1.43–1.82.

Diagnosis of adult

PDS to *c.* 100μm long.

Description of holotype larva (Figs 1A,B, 2A–D), supplemented by paratypes

Colour in life red. Idiosoma 420 long by 215 wide; total length to tip of cheliceral blades 450.

Anterior dorsal scutum porose, smooth; anterior border rounded (a slight anterior central depression appears to be an artefact of mounting), lateral and posterior borders almost straight, smooth; posterolateral angles rounded. AM scutalae stout, smooth, pointed, tusk-like; other scutalae of anterior scutum tapering, pointed, thinner, AL setae smooth, PL setae with a few fine setules. Sensillary setae filamentous.

Posterior dorsal scutum (scutellum) porose, semicircular, with smooth borders; anterior border straight, anterolateral angles rounded, posterior border convex; with two scutalae similar to PLs of anterior dorsal scutum.

Metric data as in Table 1.

Each eye pair posterolateral to anterior dorsal scutum; eyes rounded, anterior 11 across, posterior 7.

Dorsum of idiosoma behind scutellum with *c.* 20 setae, strong, tapering, pointed, with slender, outstanding setules; each seta arising from a conical papule; setae arranged 2, 2, 6, 2, 4, 2, 2 (pygosomals).

Ventral surface of idiosoma (Fig. 2A): between coxae III two slender, pointed setae, 70 long, with slender setules. Behind coxae III are eight setae, similar to dorsals, arising from papillae, 70–75 long, arranged 2, 4, 2 (pygosomals).

Legs of usual trombidioid stature. Leg lengths (including coxae and claws): I 475, II 450, III 490. Medial coxala I 65 long, bearing 15–16 long, thin, pointed digitations, arising somewhat obliquely to main axis (Fig. 2C). Lateral coxala I arises at anterolateral angle of coxa, slender, pointed, *c.* 90 long, with a few long, slender setules; above posterior cornu of coxal joint a thin, pointed supracoxala, 13 long. Urstigma at posterolateral angle of coxa I, narrow, curved, 36 long by *c.* 15 wide. Coxa II with two slender, pointed setae with a few slender setules; anterior seta 73 long, posterior seta 75 long. Coxala III similar, 80 long. Leg scobalae curved, tapering, pointed, with slender setules. Scobalar formula (legs I, II, III): Fe 5, 4, 4, Ge 4, 3, 3, Ti 5, 5, 5.

Leg specialized setae: SoGeI.26d(40), SoGeI.57ad(33), VsGeI.73d(9), SoTiI.49d(33), SoTiI.79d(27), VsTiI.88pd(*c.*5). SoGeII.45d(36), VsGeII.83d(10), SoTiII.33d(*c.*33), SoTiII.63d(*c.*23); Vs absent. SoGeIII.44d(27).

Tarsus I with SoTaI.56d(34), FaTaI.59ad(*c.*2), SeTaI.74d(43) ('tectal eupathidala'), Pt 20 long. Tarsus II with SoTaII.46d(*c.*27), FaTaII.46pd(2). Tarsal claws smooth, falciform, equal; empodium of each tarsus over-reaching claws.

Gnathosoma: combined cheliceral bases spindle-shaped, 78 long by 58 across. Cheliceral digits curved, 46 long, with apical 'chisel end'. Protorostral setae simple, curved, pointed, *c.* 13 long. Deutorostral setae absent. Tritorostral setae (Fig. 2B) curved, 25 long, with a brush of setules in distal 2/3. Behind posterior margin of palpal trochanter a simple, pointed seta (blunted in holotype) (palpal supracoxala) 4–5 long.

Palpi compact; femur with dorsal, simple, pointed seta 13 long. No genual setae. Tibia with three simple setae. Odontus strongly curved, with two divergent tines (Fig. 2D). Palpal tarsus with six pointed setae, three with a scythe-like appearance, also one or two minute blunted projections (?solenoidalae).

Description of adult female ACB294A, slide-mounted, supplemented by ACB585A (Figs 3, 4A–F)

Colour in life red. Idiosoma 3400 long by 2000 wide; total length to tip of cheliceral blades 3750.

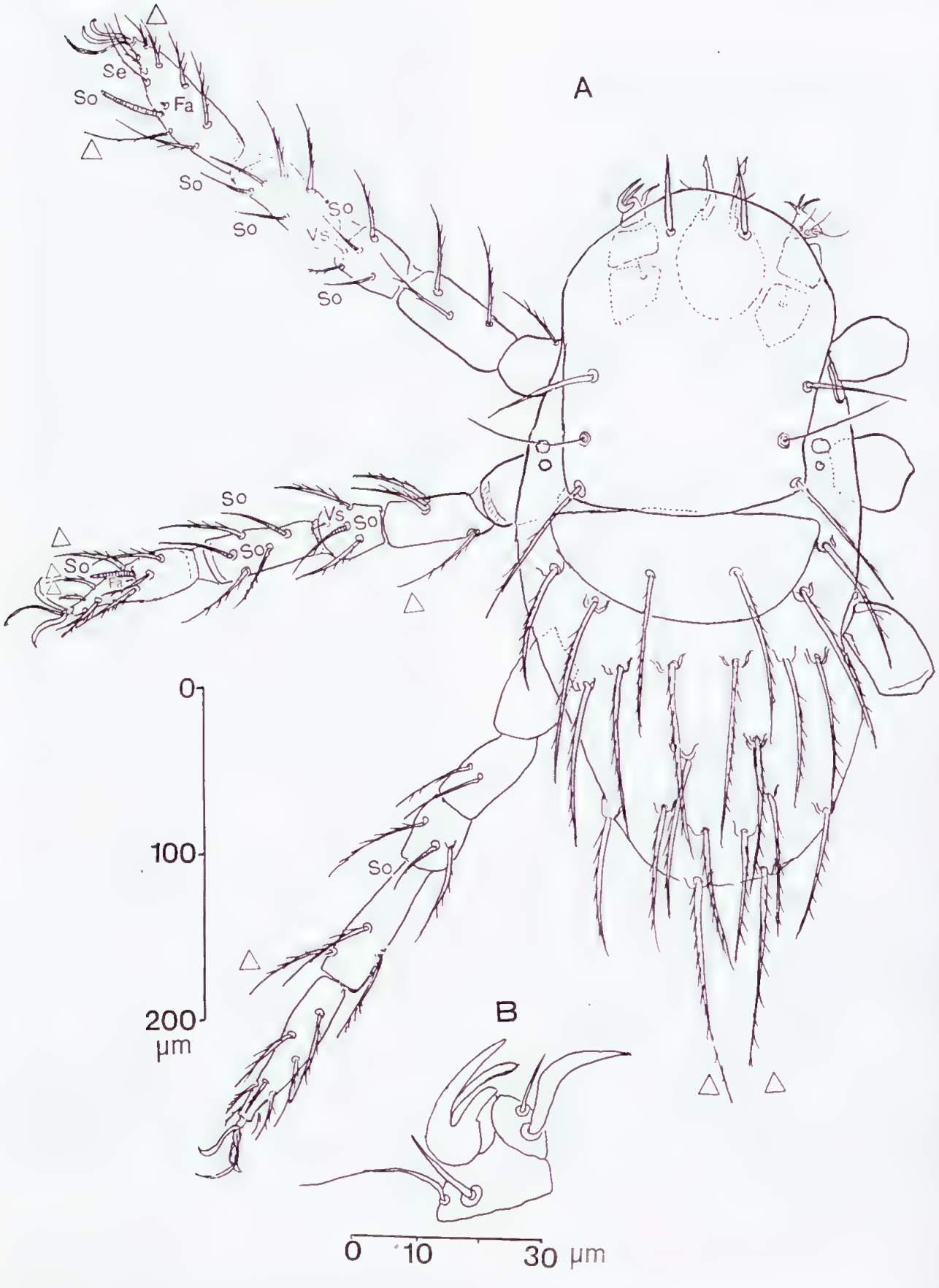

FIGURE 1. *Paratrombium australe* sp. nov., larva, holotype. **A**, Dorsal view, to standard symbols; on right, legs omitted beyond trochanters. **B**, Palpal tibia and tarsus, dorsomedial aspect, further enlarged.

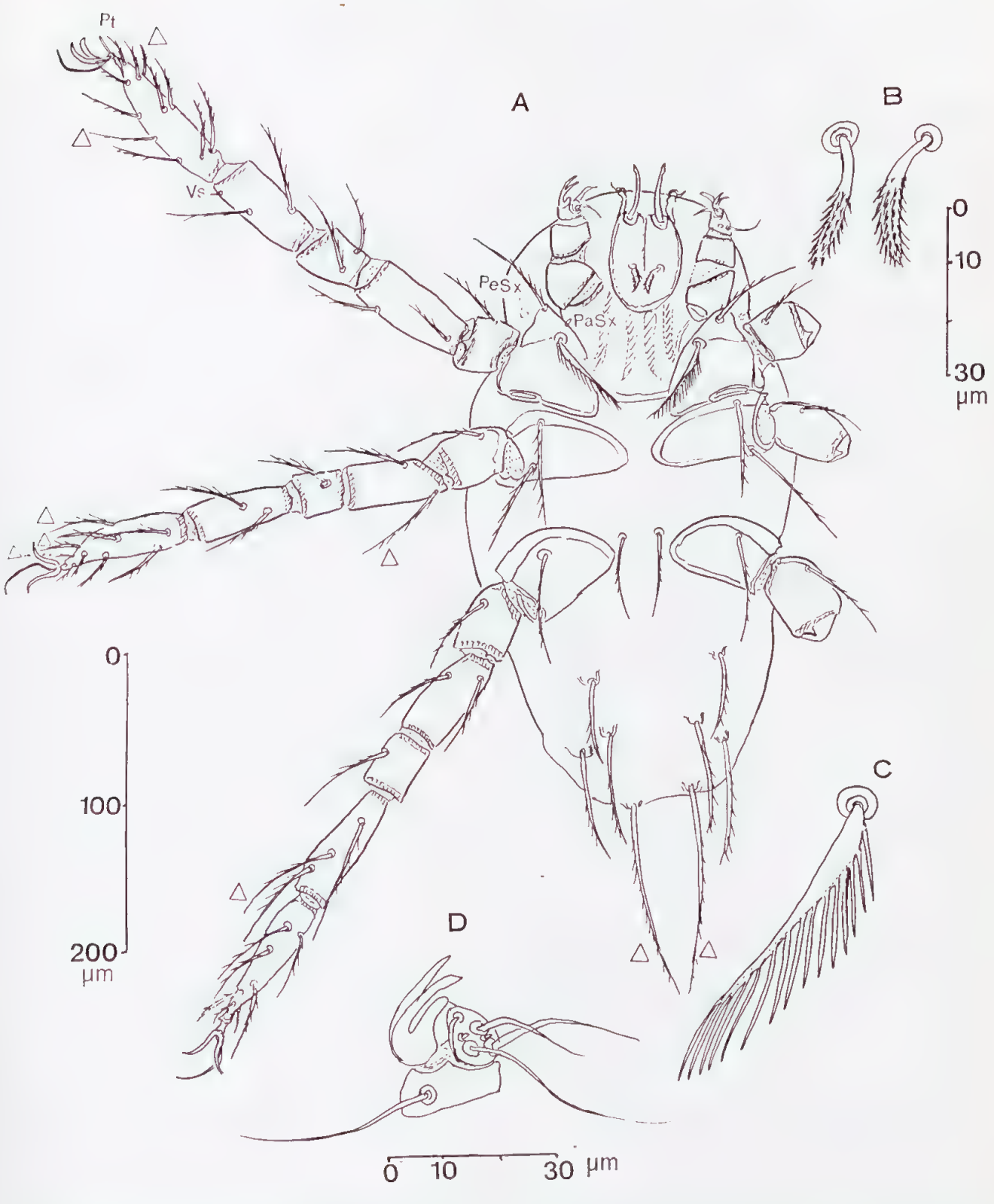

FIGURE 2. *Paratrombium australe* sp. nov., larva, holotype. **A**, Ventral view, to standard symbols; on right, legs omitted beyond trochanters. **B**, Tritorostral setae. **C**. Medial coxala I. **D**, Palpal tibia and tarsus, ventrolateral aspect. (PaSx palpal supracoxala; PeSx pedal supracoxala). (Each to nearest scale.)

Crista well developed, with strong, broad, crescentic, transverse anterior extension ('vomer') carrying pointed setulose setae 28–42 long in its anterolateral parts; more posteriorly the vomer is poorly defined, and carries similar setae to 150 long (Fig. 4A). Sensillary setae filiform, arising from a well-defined expansion of the crista; posterior end of crista well-defined, blunt-ended, Each eye pair on a large peduncle, with a lens, at about the middle, 64 across and a distal eye 60

TABLE 1. Metric data of *Paratrombium australe* sp. nov., larvae (* for maximum values).

	Population from topotype area, Myponga, S.A.						Population from Workanda Creek, S.A.				
Character	Holotype	n	range	mean	s.d.	c.v.	n	range	mean	s.d.	c.v.
LN	27	7	22–27	24.4	2.15	8.5	12	19–24	22.0	1.13	5.1
MA	98	7	97–104	100.6	2.94	2.9	12	93–105	99.8	3.47	3.5
AW	136	7	133–143	137.4	3.41	2.5	12	126–135	130.8	2.93	2.2
PW	136	7	127–143	134.6	5.03	3.7	12	125–139	132.2	4.30	3.3
SB	114	7	114–125	117.6	3.60	3.1	12	107–118	113.3	3.68	3.2
MSA	91	7	85–92	89.3	2.63	2.9	12	82–95	89.8	3.74	4.2
ASB	149	7	144–153	148.1	3.58	2.4	12	139–151	145.8	3.19	2.2
PSB	46	7	40–46	42.0	2.08	5.0	12	38–45	40.6	2.39	5.9
L	195	7	184–195	190.1	4.56	2.4	12	182–192	186.3	2.87	1.5
W	176	7	172–178	175.0	2.31	1.3	12	162–170	165.5	3.26	2.0
AP	61	7	59–62	60.6	3.21	5.3	12	59–67	63.9	2.71	4.2
SA	31	7	31–34	33.3	2.36	7.1	12	31–40	34.5	2.81	8.2
SP	34	7	27–34	29.9	2.61	8.7	12	25–34	31.5	2.39	7.6
AM	45	7	44–48	45.6	1.27	2.8	6	38–45	43.3	2.73	6.3
AL	53	7	47–57	52.3	3.20	1.9	12	44–56	48.2	3.90	8.1
PL	82	7	80–93	84.0	5.57	6.7	12	77–93	84.2	5.01	5.9
AMB	47	7	43–48	45.9	1.77	3.9	11	38–46	42.7	2.15	5.0
SE	75	7	60–73	66.4	5.80	8.7	10	62–77	70.0	4.67	6.7
PLN	42	7	40–46	43.4	2.30	5.3	11	38–47	42.9	2.43	5.7
PSL	74	7	71–78	74.0	2.16	2.9	11	69–74	72.2	1.89	2.6
PSW	164	7	159–166	162.9	2.91	1.8	12	152–164	157.1	3.20	2.0
QW	53	7	50–58	53.4	2.51	4.7	12	43–55	50.1	4.36	8.7
QL	91	7	81–91	84.6	3.87	4.6	12	69–85	79.8	4.69	5.9
DS	77–160	7	144–160*	151.7*	6.78*	4.5*	12	141–158*	150.9*	6.13*	4.1*
MDS	80	7	75–82	81.0	2.89	3.6	12	68–90	77.8	7.28	9.4
PDS	160	7	144–160	151.7	6.78	4.5	12	141–158	150.9	6.13	4.1
AW/QW	2.57	7	2.33–2.72	2.58	0.131	5.1	12	2.31–3.07	2.66	0.222	8.4
PSL/PLN	1.76	7	1.58–1.88	1.71	0.103	6.0	11	1.59–1.83	1.69	0.0890	5.3
FeI	91	7	96–93	90.6	2.37	2.6	12	86–98	90.7	3.87	4.3
GeI	51	7	51–60	55.1	2.61	4.7	12	51–57	53.3	1.97	3.7
TiI	82	7	78–82	81.6	4.47	5.5	12	82–90	84.4	2.61	3.1
TaI(L)	110	7	107–113	110.3	2.14	1.9	12	109–118	115.1	3.34	2.9
TaI(H)	54	7	29–34	32.0	1.73	5.4	12	26–30	27.6	0.996	3.6
TiI/GeI	1.61	7	1.42–1.61	1.48	0.0678	4.6	12	1.49–1.64	1.59	0.0478	3.0
FeII	77	7	75–77	76.1	0.900	1.2	12	70–83	77.1	3.75	4.9
GeII	43	7	43–47	44.3	1.60	3.6	12	42–48	44.3	1.83	4.1
TiII	77	7	71–77	74.4	2.30	3.1	12	73–82	77.2	2.95	3.8
TaII(L)	96	7	95–99	96.7	1.38	1.4	11	95–104	100.5	2.94	2.9
TaII(H)	26	7	25–27	25.9	0.690	2.7	12	22–25	23.1	0.996	4.3
TiII/GeII	1.79	7	1.57–1.79	1.68	0.0819	4.9	12	1.52–1.85	1.74	0.0844	4.8
FeIII	83	7	82–85	83.1	1.21	1.5	12	82–92	85.8	2.89	3.4
GeIII	46	7	46–51	47.6	1.90	4.0	12	48–53	48.8	2.82	5.8
TiIII	93	7	88–95	90.7	2.81	3.1	12	87–96	92.3	2.83	3.1
TaIII(L)	102	7	93–107	101.3	4.50	4.4	12	93–111	103.4	5.25	5.1
TaIII(H)	24	7	22–24	23.0	0.577	2.5	12	18–23	20.8	1.54	7.4
TiIII/GeIII	2.02	7	1.78–2.02	1.91	0.0963	5.0	12	1.75–2.13	1.89	0.105	5.5
SA/SP	0.91	7	0.91–0.23	1.12	0.116	10.3	12	0.91–1.33	1.10	0.173	15.7
AW/AMB	2.89	7	2.83–3.16	3.00	0.139	4.6	11	2.89–3.52	3.11	0.191	6.1
QL/QW	1.72	7	1.41–1.72	1.59	0.108	6.8	12	1.45–1.93	1.60	0.164	10.2
PSW/QW	3.09	7	2.74–3.18	3.05	0.146	4.8	12	2.82–3.63	3.16	0.270	8.6
MA/AP	1.61	7	1.48–1.62	1.66	0.128	7.7	12	1.43–1.71	1.51	0.910	5.8

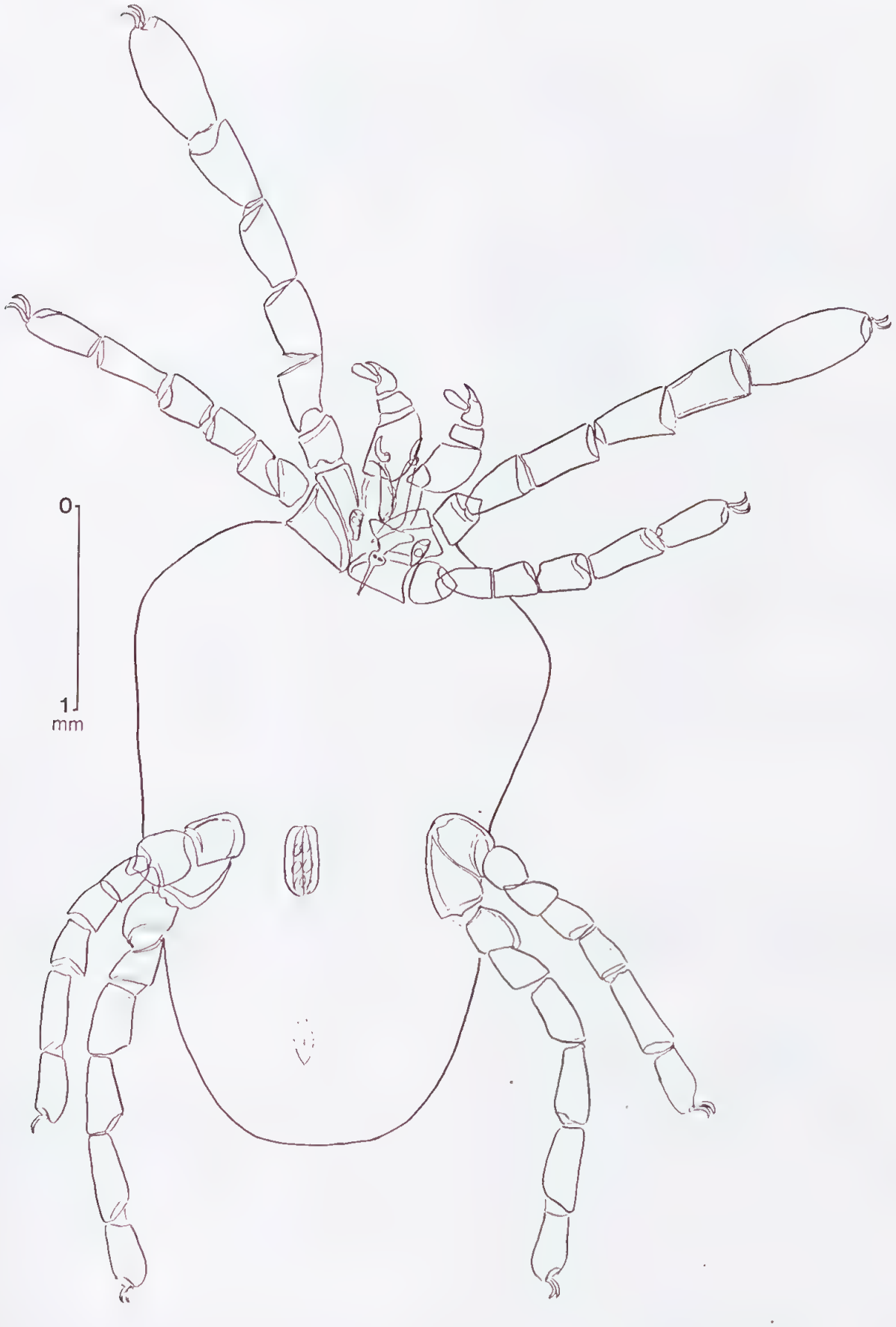

FIGURE 3. *Paratrombium australe* sp. nov., adult female, paratype, in transparency, setae omitted.

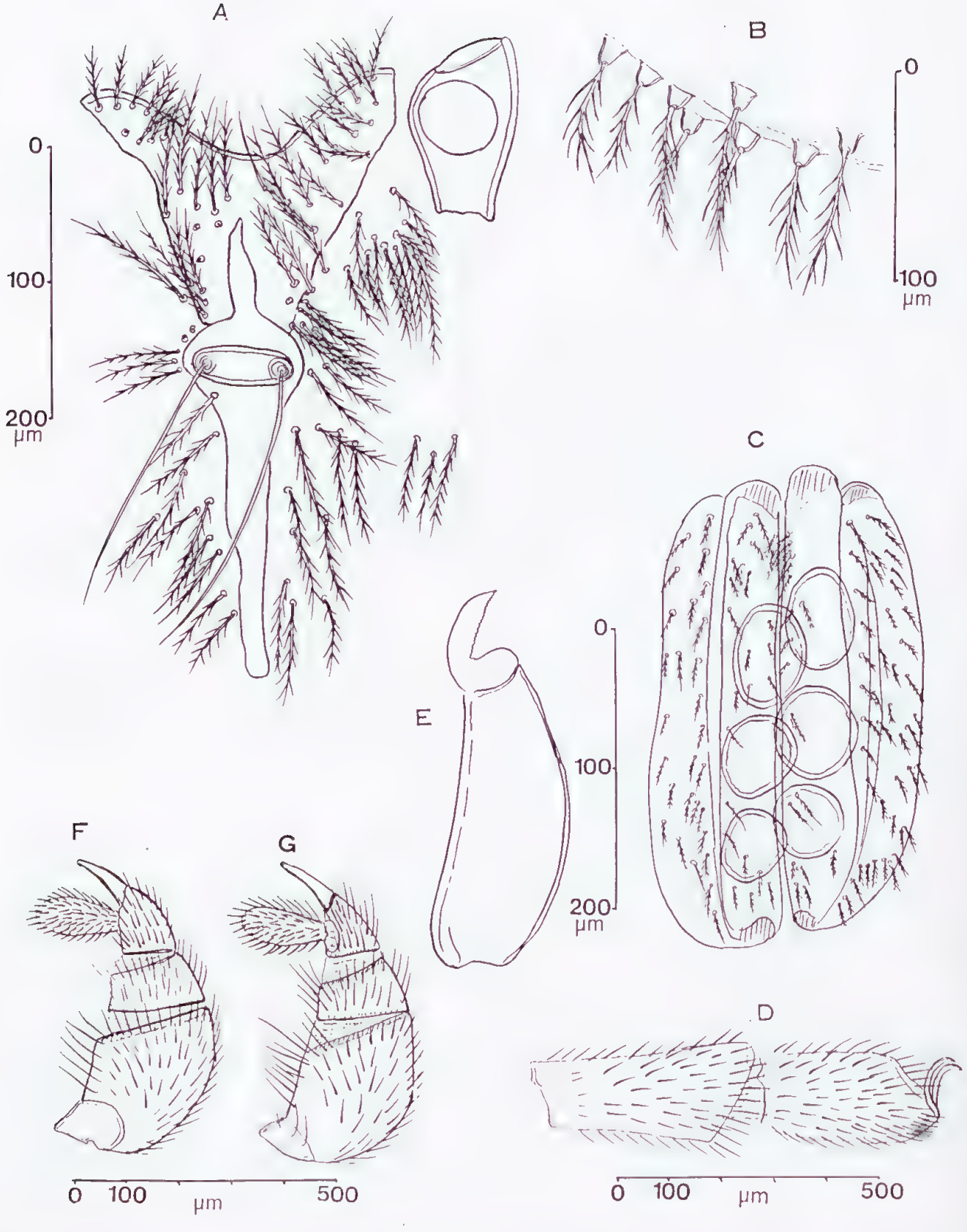

FIGURE 4. *Paratrombium australe* sp. nov., adult female, paratype. **A**, Crista and adjacent structures. **B**, Posterior dorsal idiosomal setae. **C**, External genitalia. **D**, Tibia IV and tarsus IV. **E**, Palp, dorsomedial aspect. **F**, Palp, ventrolateral aspect. (Each to nearest scale.)

across, terminal.

Dorsum of idiosoma thickly invested with pointed, tapering, well setulose setae (Fig. 4B).

Metric data as in Table 2.

Venter of idiosoma with setation similar to dorsal. External genitalia (Fig. 4C) oblong in outline, with rounded angles, 375 long by 220 wide; valves carry numerous setulose setae; genitalia with three pairs of subequal acetabula; anterior acetabulum oval, 82 x 55, middle oval 73–80 x 60–65, posterior near-circular, 65 x 45 and 60 x 58. Anus about 160 long by 60 wide.

TABLE 2. Metric data of *Paratrombium australe* sp. n., adults (CL = crista length; VW = vomer width).

Character	Described specimen ACB294A	Specimen ACB585A
CL	468	–
VW	256	331
ASB	222	229
PSB	246	–
SB	62	66
SE	*c.* 230	275
EPL	155	195
EPW	83	85
MDS	70–100	*c.* 80
PDS	70–100	*c* 100
GeI	440	540
TiI	485	540
TaI(L)	684	735
TaI(H)	275	324
TiI/GeI	1.08	1.00
TaI(L)/TiI	1.43	1.36
TaI(L)/TaI(H)	2.48	2.27
GeII	310	360
TiII	410	480
TaII(L)	410	490
TaII(H)	175	180
TiII/GeII	1.32	1.33
TaII(L)/TiII	1.02	1.02
TaII(L)/TaII(H)	2.52	2.72
GeIII	297	333
TiIII	441	490
TaIII(L)	345	440
TaIII(H)	180	180
TiIII/GeIII	1.48	1.47
TaIII(L)/TiIII	0.78	0.90
TaIII(L)/TaIII(H)	1.92	2.44
GeIV	425	490
TiIV	454	684
TaIV(L)	367	440
TaIV(H)	184	209
TiIV/GeIV	1.07	1.40
TaIV(L)/TiIV	0.81	0.64
TaIV(L)/TaIV(H)	1.99	2.11

Legs shorter than idiosoma; lengths (trochanter to claw tips: I 2665, II 1850, III 1865, IV 2270. Legs thickly invested with pointed, setulose setae. Tarsal claws smooth, falciform, about equal in size over legs I–IV.

Gnathosoma: chelicerae (Fig. 4E) robust, bases 230 long by about 110 wide (combined). Cheliceral digits falciform, 86 long, with fine dorsal denticles. Palpi (Fig. 4F,G) robust, all segments heavily invested with pointed, setulose setae. Palpal tibia with blunted odontus, but without paradonts or spinisetae. Palpal tarsus elongate–ellipsoid, 170 long by 75 wide, over-reaching odontus.

Description of ovum

Colour red or pink; smooth, polished, spheroidal, about 300–350 long by 250 wide (estimated from egg-skins of ACB294 and ACB585).

Description of prelarva

Colour red; appearance normal (size not measured).

Etymology

The specific name *australe* is an adjective, signifying that all specimens described originated in southern Australia (in fact, a limited area in South Australia).

Remarks

Table 2 gives the metric data of two adult females of *P. australe,* both of which produced ova which hatched to larvae, and used in the metric data of Table 1. See below on the discussion of the taxonomy of the adults of *Paratrombium*..

Biology

Two adult females of *P. australe* have been captured in the field, ACB294A and ACB585A, from which larvae were reared experimentally. In addition, batches of ova have been collected in the field, from which larvae of *P. australe* emerged. Details of these successful rearing experiments are as follows.

Experiment ACB294: Two adult mites were captured in close proximity on 12.x.1947. The larger one was the female ACB294A, and the smaller one ACB295 (assumed to be a male), from among damp bark in eucalypt forest (now the Nixon-Skinner Reserve). They were placed

together in a small tube with some damp soil from the site of capture.

On 17.x.1947 I recorded 'The female mite is resting on the cork, its abdomen somewhat shrunken. The male mite is resting on the glass, alongside the female, its front legs touching the front legs of the female. Not in coitus. On the damp bark is a large mass of light orange–red eggs, some hundreds. [They are] smooth, spheroidal, polished. The volume of the eggs is about twice the volume of the female! Yet they are so obvious as a body that they have obviously been laid by the large mite. Eggs are of uniform colour throughout the mass. Even if the smaller mite is not a male, none the less the eggs belong to the larger mite.'

On 26.x.1947 it was recorded that no further ova had been laid, and the ova remained undifferentiated. The smaller mite had been seen over the previous few days mounted on the back of the female.

On 2.xi.1947 the adults appeared healthy. A few ova were showing the 'earliest signs of colour differentiation', i.e. one side darker, the other lighter. There were a few mould filaments on the ova.

On 9.xi.1947 the ova were not further differentiated, and no further ova had been laid. The smaller mite was immobile, probably dead. On 14.xi.1947 the ova had become irregular in shape, and were recorded as containing developing legs. The smaller mite became mouldy, and was removed from the tube and preserved. The female mite was recorded as 'sluggish'.

Thereafter the deutova ('eggs') were observed daily. The developing legs became more prominent, and the eye spots developed. On 29.xi.1947 several larvae emerged; seven were mounted. On 30.xi.1947 a further group of larvae (about 20) had emerged. The adult female remained alive, but was not parasitized by the larvae; on 5.xii.1947 her movements were uncoordinated, and by 9.xii.1947 she had died. All larvae had emerged by 9.xii.1947, and were recorded as active and healthy. Their strongly positive phototropism (to both suffused natural and artificial (tungsten) light) allowed batches to be transferred to other tubes in efforts to find suitable arthropod hosts. As possible hosts small beetles, a mantispa, various Diptera, Jassidae (Hemiptera) and an immature locust were offered. Of these, the larvae attached only to the mantispa.

Experiment ACB585: A large adult was captured running across the ground on 30.viii.1953, and placed in a tube with some local soil. On 30.x.1953 (the next recorded observation) the adult was dead, and the tube contained also 'a loose aggregate of red eggs' in an advanced prelarva stage. A number of these emerged to larvae. The tube was allowed to dry out, and the adult and larvae later mounted by standard procedures.

Experiment ACB546: A batch of ova was collected from soil on 27.x.1951, and placed in a small tube with some local soil. A month later (25.xi.1951) they were recorded as pink, smooth and unshrunken. On 5.xii.1951 a few ova were observed to be in the prelarva stage 'but most are not'; all were unhatched; a few were mouldy. On 10.xii.1951 all had transformed to prelarvae; they were still in this stage on 21.xii.1951. On 23.xii.1951 'five larvae have hatched; others unhatched'.

On 25.xii.1951 'Tube is swarming with larval trombidiids'; a few ova were still unhatched. I added a green-eyed lacewing (Neuroptera, Chrysopidae) to the tube. It promptly ate several larvae, and was not attacked by them.

A series of attempts to find suitable host arthropods was made. As before, this was made possible by the larvae being 'attracted to light'. Larvae successfully parasitized adults of *Musca domestica* L. (head, neck, thorax, abdomen, wings, legs), also other smaller Diptera, including a small hover fly (Syrphidae), as well as a small golden-green wasp, but not a thysanuran (Lepismatidae), a jassid (*Typhlocyba* sp., Hemiptera) or various other small Hemiptera. Although some of the larvae fed on their hosts and increased in size, none progressed to a later instar.

Two other batches of ova (ACB545 and ACB547) were collected at the same site, but in captivity became mouldy and did not transform to prelarvae.

In summary, ova are laid in October–November in the South Australian areas studied. They develop into prelarvae in some weeks, and larvae emerge in November–December. No larva has been captured ectoparasitic on an arthropod in the field, but experimentally they will parasitize Diptera, small Hymenoptera and a species of Mantispidae.

Paratrombium lindsayi sp. nov
(Figs. 5, 6A–F, 7, 8A–F)

Material examined

Holotype. South Australia: Glenunga,

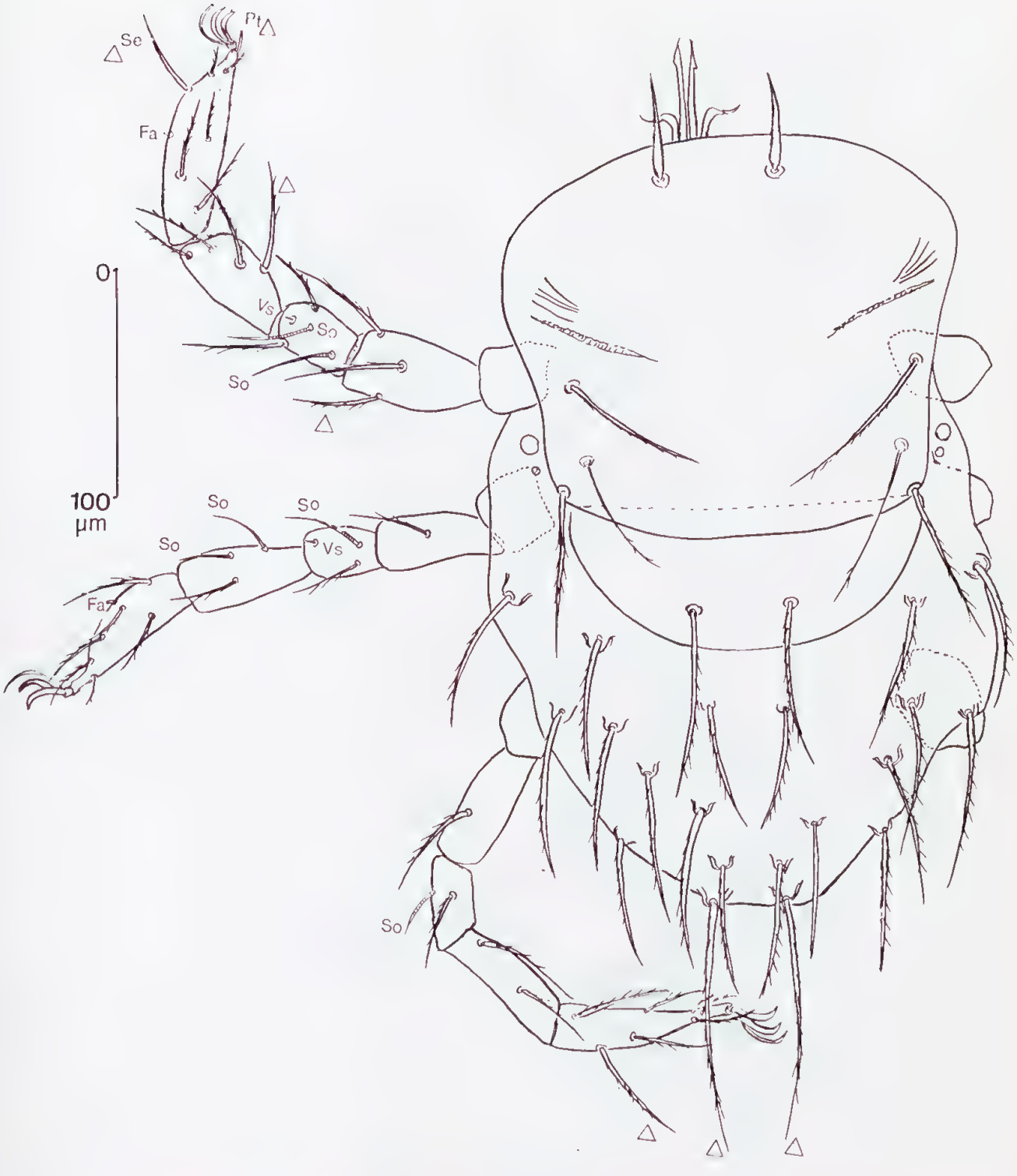

FIGURE 5. *Paratrombium lindsayi* sp. nov., larva, holotype. Dorsal view, to standard symbols; on right, legs omitted beyond trochanters.

November, 1951, reared larva ACB549L3, reared from ova laid by ACB549A, A. Lindsay Southcott. SAM.

Paratypes. Same locality and collector, adult female ACB549A, 28.x.1951; reared larvae (as for holotype) ACB549L1, 2, 4–8. SAM.

Diagnosis of larva

Scutellum with two setae. Posterior claw of tarsus III not reduced. AM setae thickened, pointed, tusk-like. Medial coxala I with 27–28 digitations. Odontus strong, curved, with two diverging tines. Tritorostral setae curved, pointed,

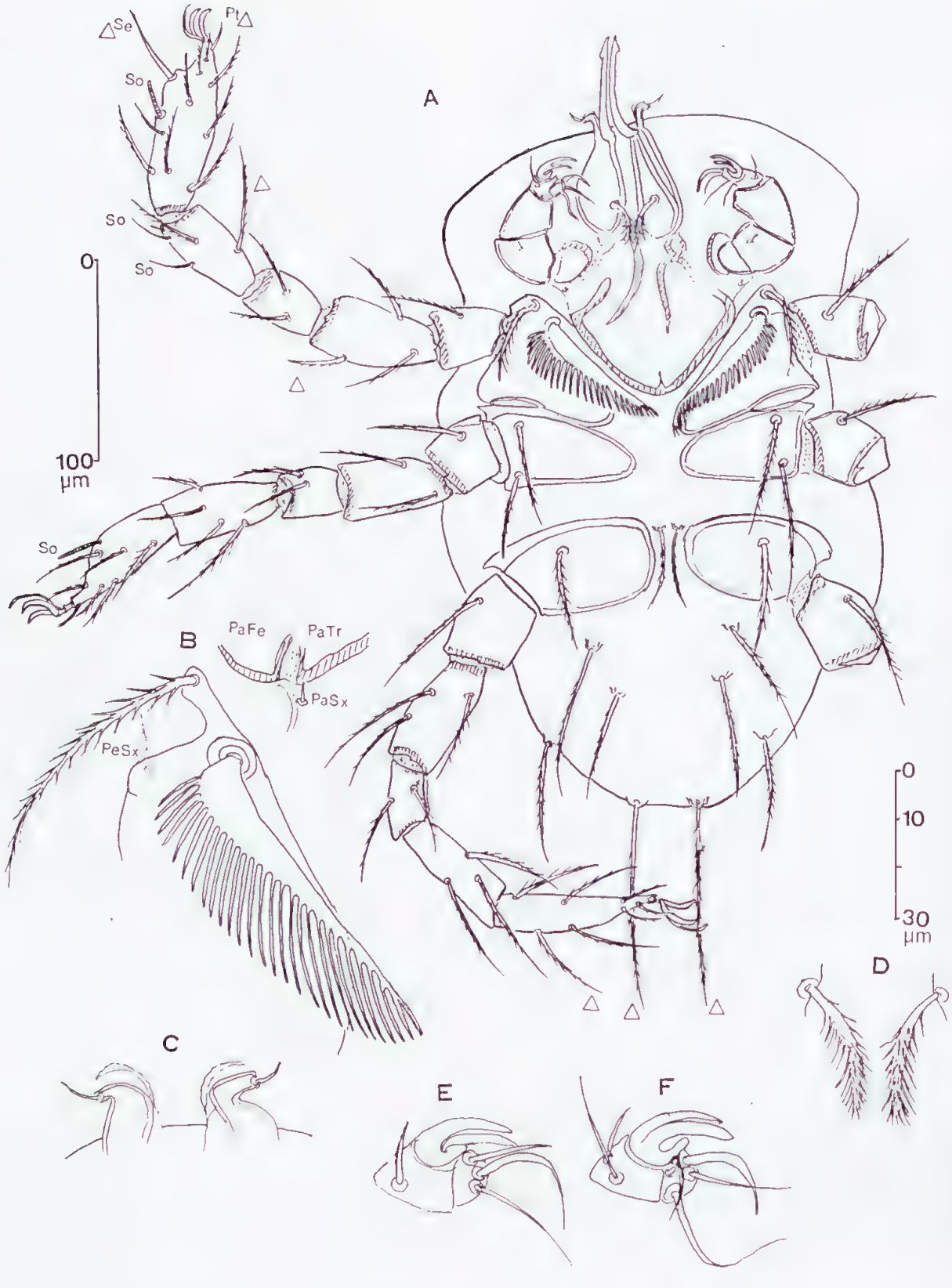

FIGURE 6. *Paratrombium lindsayi* sp. nov., larva, holotype, to standard symbols. **A**, Ventral view, on right legs omitted beyond trochanters. **B**, Medial coxala I and adjacent structures. **C**, Tip of rostrum and protorostral setae. **D**, Tritorostral setae. **E**, Palpal tibia and tarsus, dorsomedial aspect. **F**. Palpal tibia and tarsus, ventrolateral aspect. (PaFe palpal femur; PaTr palpal trochanter; PaSx palpal supracoxala; PeSx pedal supracoxala). (A to scale on left; B–F to scale on right.)

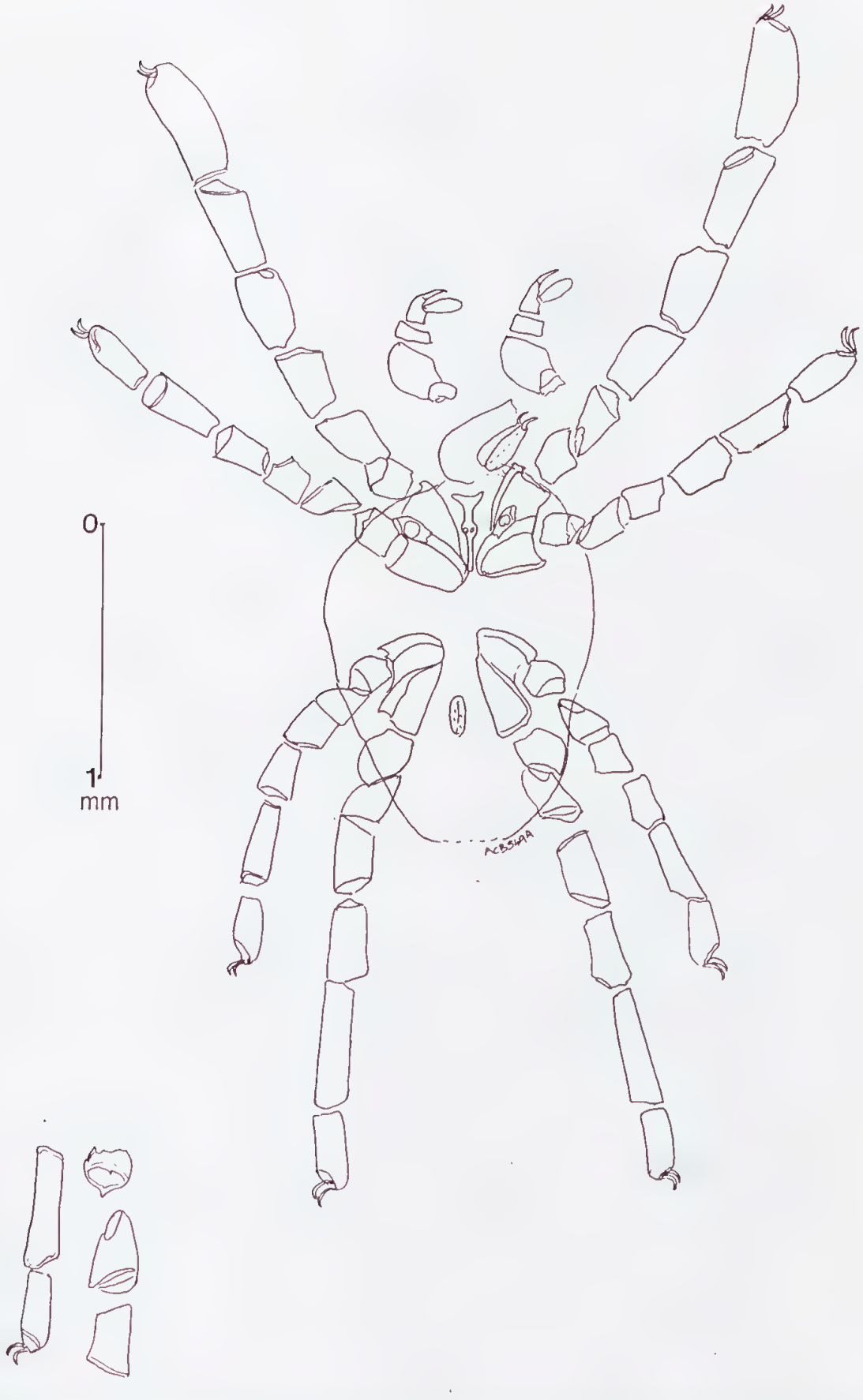

FIGURE 7. *Paratrombium lindsayi* sp. nov., adult female, paratype. In transparency; figure assembled from largely disarticulated pieces; inset: surplus fragments of another adult trombidioid present in the experimental tube (see text). (All to scale shown.)

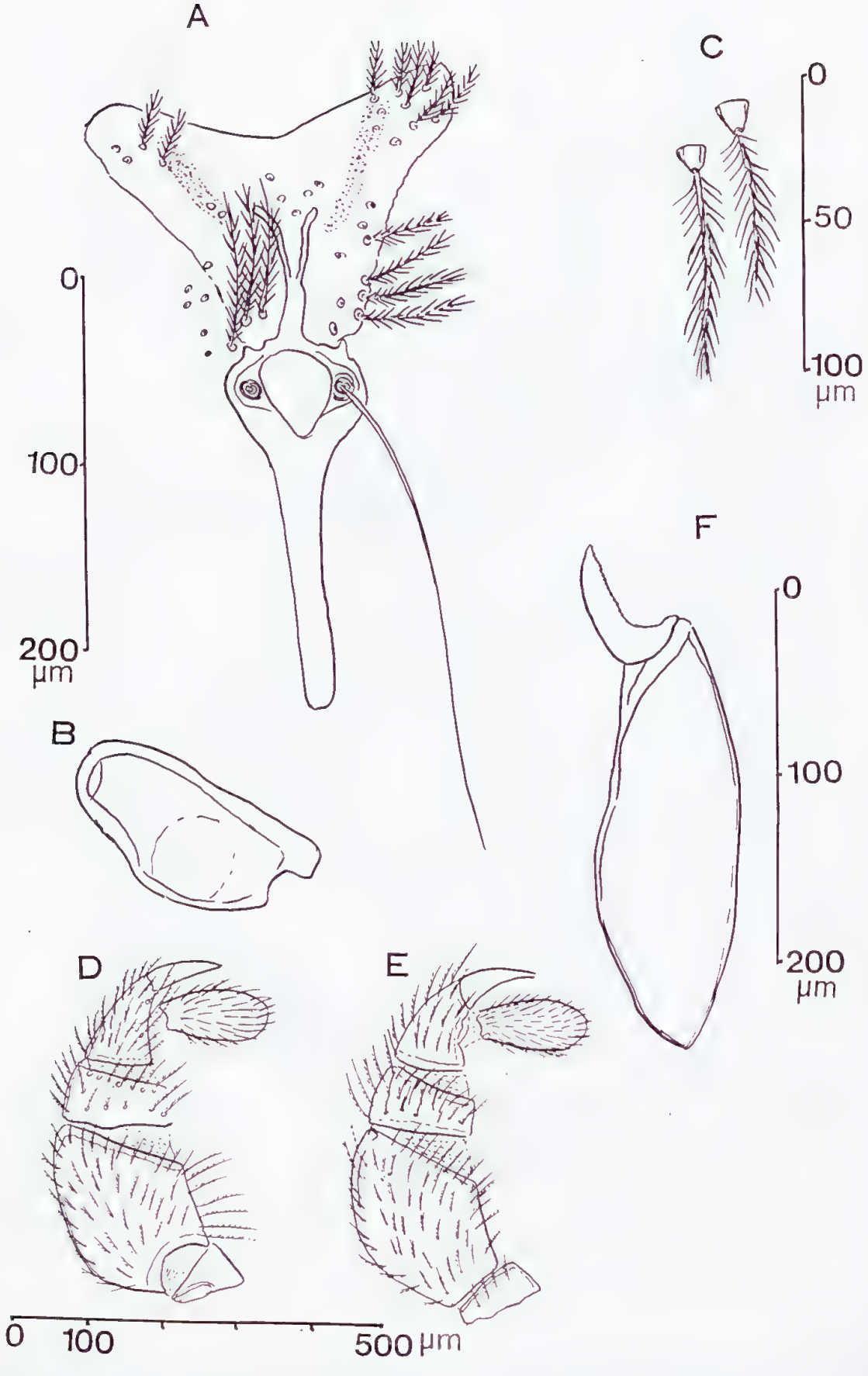

FIGURE 8. *Paratrombium lindsayi* sp. nov., adult female, paratype. **A**, Crista. **B**, Ocular peduncle. **C**, Two posterior dorsal idiosomal setae. **D**, Palp, dorsomedial aspect. **E**, Palp, ventrolateral aspect. **F**, Chelicera. (Each to nearest scale.)

with a leash of setules in distal half. MA/AP 1.84–2.29.

Diagnosis of adult

PDS to 80 μm long.

Description of larva, slide-mounted (from holotype, supplemented by paratypes) (Figs 5, 6A–F)

Colour in life red. Idiosoma ovoid, length 367, width 230; total length 417.

Dorsal scutum approximately square in outline, with rounded angles. Margins smooth, anterior margin convex, lateral margins weakly concave, posterior margin convex. Scutum finely porose, the only special markings being an oblique pleat laterally, anterior to middle of scutum, and a few curved striae anterior to it. AM setae smooth, pointed, tusk-like; AL and PL setae tapering, pointed, with a few slender, pointed setules. Sensillary setae filiform, with a few slender, distal setules.

Each eye pair near posterolateral border of scutum; anterior eye 11 across, posterior 8.

Metric data as in Table 3.

Scutellum transverse, with smooth margins; anterior border almost linear, posterior border stongly convex, lateral angles rounded; scutum porose, without special markings; scutalae similar to AL and PL scutalae of anterior dorsal scutum.

Dorsum of idiosoma behind scutellum with 20 setae, tapering, pointed, with a few lightly outstanding setules; setae arranged 2, 2, 6, 2, 4, 2, 2 (pygosomals).

Ventral surface of idiosoma (Fig. 6A): two setae (intercoxalae) between medial ends of coxae III, slender, tapering, setulose, 45 long, with long, pointed setules. Behind coxae III are setae similar to dorsals, 54–57 long, arranged 2, 4 (+ two pygosomals).

Legs of usual stature for genus; lengths (including coxae and claws) I 410, II 360, III 410. Coxa I with medial coxala I arising towards anterolateral angle, 71 long by 27 wide where widest, with *c.* 27 digitations (Fig. 6B), the proximal digitations arising almost at right angles to axis, distal ones arising more obliquely, all pointed; lateral coxala I arising close to anterolateral angle of coxa, 73 long, curved, pointed, well setulose with long setules; originating above posterior cornu of coxa-trochanteral joint a fine, pointed, simple seta (supracoxala), 15 long. Urstigma oval, 36 x 13, at posterolateral angle of coxa I. Coxa II with two pointed, setulose setae, each 55 long, anterior arising near anterolateral angle of coxa, posterior near posterolateral angle. Coxa III with a similar seta, 58 long. Leg setae pointed, setulose. Scobalar formula (legs I, II, III): Fe 5, 4, 4, Ge 4, 3, 3, Ti 5, 5, 5.

Leg specialized setae: SoGeI.24ad(42), SoGeI.50ad(33), VsGeI.77pd(*c.*7), SoTiI.54d(24), SoTiI.81d(24), VsTiI.93pd(*c.*7). SoGeII.45p(45), VsGeII.81pd(7) SoTiII.21d(34), SoTiII.50pd(25). SoGeIII.32d(40).

Tarsus I with SoTaI.56d(25), FaTaI.55ad(1), SeTaII.78d(43) ('tectal eupathidala'), Pt 11 long. Tarsus II with SoTaII.48d(18), FaTaII.48pd(1). Tarsal claws and empodium as in *P. australe.*

Gnathosoma: chelicerae bases spindle-shaped, 73 long by 55 wide (combined); cheliceral digits slender, 58 long, with 'chisel end' 13 long Protorostral setae (Fig. 6C) simple, curved, pointed, 8 long; deutorostrals absent; tritorostrals (Fig. 6D) curved, 32 long, with a brush of setules in distal 2/3. A minute, slender supracoxala, 7 long, behind posterolateral border of palpal trochanter (Fig. 6B). Palpal femur with slender, simple, pointed dorsal seta 13 long. Palpal tibia with three simple, slender, pointed setae. Odontus strongly curved, with two divergent tines. Palpal tarsus (Fig. 6E,F) with seven pointed setae, of which two are scythe-like; also a short peg-like projection, ?solenoidala.

Description of adult female (from paratype ACB549A, slide-mounted, largely disarticulated, but reconstituted from morphology and sizes of leg segments) (Fig. 7, 8A–F)

Colour in life red. Idiosoma more or less cordate, 1420 long by 1075 wide; length to tip of cheliceral blades 1480.

Crista (Fig. 8A) well-developed, with typical vomer spreading from anterior part; in its anterolateral part vomer carries well setulose setae 40–50 long; in its more posterior part setae are up to *c.* 80 long. Sensillary setae filamentous, originating from a well-developed boss.

Dorsum of idiosoma thickly invested with tapering, well setulose setae (Fig. 6C) Eye peduncles well developed, each with two eyes (Fig. 6B), one at middle of peduncle 64 wide, the other terminal, *c.* 64 wide.

Metric data as in Table 4.

Ventral surface of idiosoma with setation similar to dorsal. External genitalia and anus partly obscured in specimen.

Legs of normal trombidioid stature; leg lengths (trochanters to claw-tips; estimated from reconsituted specimen by fitting drawings): I

TABLE 3. Metric data of *Paratrombium lindsayi* sp. nov. larvae (*for maximum values).

Character	Holotype	n	range	mean	s. d.	c.v.
LN	22	8	18-24	21.5	2.07	9.6
MA	103	8	97-107	102.9	2.80	2.7
AW	157	8	151-162	156.6	3.46	2.2
PW	169	8	155-169	161.6	4.47	2.8
SB	141	8	132-142	137.4	3.46	2.5
MSA	93	8	91-95	92.5	1.31	1.4
ASB	146	8	140-149	146.3	3.92	2.7
PSB	40	8	40-48	43.8	2.60	6.0
L	186	8	184-196	190.0	5.10	2.7
W	212	8	205-217	211.6	4.21	2.0
AP	45	8	45-56	52.3	3.37	6.4
SA	39	8	34-39	35.6	1.77	5.0
SP	22	8	21-25	22.6	1.19	5.2
AM	40	8	40-51	44.4	3.46	7.8
AL	55	8	48-57	53.0	3.55	6.7
PL	80	8	77-82	78.6	1.92	2.4
AMB	54	8	49-59	54.1	2.95	5.4
SE	60	8	80-92	88.6	4.00	4.5
PLN	*c.* 35	8	27-38	35.1	4.02	11.4
PSL	*c.* 55	8	46-69	59.3	6.50	11.0
PSW	*c.* 189	8	176-192	182.3	6.18	3.4
QW	59	8	54-60	57.1	2.30	4.0
QL	82	8	77-83	80.0	2.39	3.0
DS	75-125	8	109-127*	117.8*	7.01*	5.9*
MDS	75	8	66-76	74.0	3.25	4.4
PDS	125	8	109-127	117.8	7.01	5.9
AW/QW	2.66	8	2.57-2.89	2.72	0.0997	3.7
PSL/PLN	*c.* 1.57	8	1.57-1.78	1.69	0.0614	3.6
FeI	74	8	69-77	73.9	2.59	3.5
GeI	45	8	42-48	44.3	2.19	4.9
TiI	70	8	66-73	70.0	2.83	4.0
TaI(L)	91	8	86-91	90.0	1.77	2.0
TaI(H)	29	8	26-31	28.9	1.46	5.0
TiI/GeI	1.56	8	1.47-1.74	1.59	0.100	6.3
FeII	62	8	59-64	60.9	3.09	5.1
GeII	40	8	35-40	36.6	1.51	4.1
TiII	62	8	58-63	60.4	2.07	3.4
TaII(L)	76	8	73-80	76.8	2.05	2.7
TaII(H)	22	8	20-23	22.1	1.13	5.1
TiII/GeII	1.55	8	1.55-1.75	1.65	0.060	3.7
FeIII	69	8	64-70	67.3	2.38	3.5
GeIII	44	8	37-45	41.4	2.50	6.1
TiIII	73	8	69-75	71.8	2.05	2.9
TaIII(L)	84	8	78-86	82.4	2.72	3.3
TaIII(H)	22	8	18-22	20.1	1.25	6.2
TiIII/GeIII	1.66	8	1.53-1.95	1.74	0.123	7.1
SA/SP	1.77	8	1.36-1.77	1.58	0.120	7.6
AW/AMB	2.91	8	2.68-3.16	2.90	0.169	5.8
QL/QW	1.39	8	1.28-1.50	1.40	0.0676	4.8
PSW/QW	3.20	8	3.00-3.40	3.19	0.119	3.7
MA/AP	1.87	8	1.84-2.29	1.95	0.150	7.6

TABLE 4. Metric data of *Paratrombium lindsayi* sp. nov., adult, compared with adult *Paratrombium nynganense* (Hirst). ([A] Data from Hirst (1928a). [B] Figures in parenthesis are derived from the disarticulated segments, after reconstitution and re-assessment of the largely disarticulated specimen. [C] Womersley (1934). CL = crista length; VW = vomer width).

Specimen	*Paratrombium lindsayi* ACB549A[B]	*Paratrombium nynganense*
Character		
CL	352	
VW	195	
ASB	165	
PSB	187	
SB	50	
SE	210	
EPL	128	
EPW	75	
MDS	–	
PDS	75–80	65[C]
GeI	(373)	
TiI	(432)	260[A]
TaI(L)	(565)	350[A]
TaI(H)	(203)	120[A]
TiI/GeI	(1.16)	–
TaI(L)/TiI	(1.31)	1.35[A]
TaI(L)/TaI(H)	(2.78)	2.92[A]
GeII	(245)	
TiII	(360)	
TaII(L)	320	
TaII(H)	139	
TiII/GeII	(1.47)	
TaII(L)/TiII	(0.89)	
TaII(L)/TaII(H)	2.30	
GeIII	(237)	
TiIII	(380)	
TaIII(L)	(290)	
TaIII(H)	(138)	
TiIII/GeIII	(1.60)	
TaIII(L)/TiIII	(0.76)	
TaIII(L)/TaIII(H)	(2.10)	
GeIV	(346)	
TiIV	(530)	
TaIV(L)	324	
TaIV(H)	140	
TiIV/GeIV	(1.53)	
TaIV(L)/TiIV	(0.61)	
TaIV(L)/TaIV(H)	2.31	

2145, II 1605, III 1405, IV 1900. Tarsal claws as described for *P. australe*.

Gnathosoma: combined chelicerae bases spindle-shaped, *c.* 200 long by 73 wide; cheliceral digits robust, 80 long, with fine, dorsal retrorse denticles (Fig. 8F). Palpi (Fig. 8D,E) robust, well covered with pointed, setulose setae; palpal tibial odontus as for *P. australe*, 130 long, without paradonts or spinisetae. Palpal tarsus 155 long by 64 wide, with numerous fine, setulose setae.

Description of Ovum

Red, spheroidal, smooth, size (estimated from cast ova skins) about 350 long by 250 wide.

Description of Deutovum

Colour red; dimensions not measured; no unusual features noted.

Etymology

The species is named for the collector, then aged 12 years.

Biology

Experiment ACB549: An adult female was captured on 28.x.1951, and confined in a small tube with some soil from the capture site. At the next observation, on 25.xi.1951, the adult was dead and the tube contained a 'Batch of red, smooth, spheroidal eggs'. On 5.xii.1951 all ova had developed to the prelarva stage; a few were mouldy. On 10.xii.1951 all had emerged to larvae. On 11.xii.1951 it was recorded that the larvae tended to aggregate in groups. An adult lacewing (Chrysopidae) placed in the tube was not parasitized by the larvae. By 16.xii.1951 all larvae had died.

The adult had been left in the tube, and had decomposed, the legs being largely disarticulated. Adult and larvae were mounted by standard procedures. The legs of the adult were mostly in individual segments, which were mounted, later to be identified by shape and measurement. In the tube were five extra leg segments, two were of a conjoined tibia IV and tarsus IV, discrepant from the others, and three segments (trochanteral and femoral) not used in the metric data in Table 4. It is assumed that the original soil used was contaminated by extra leg segments of another trombidioid mite.

Comment on the taxonomy of Paratrombium australe and P. lindsayi

Larvae: The two reared populations of larvae of *P. australe* (ACB294 and ACB585) show similar

morphological features, and in addition the metric data show overlapping ranges in almost all of the dimensions measured, so that their specific identity need not be questioned.

In the case of the larvae of *P. lindsayi* there is almost no overlap of the dimension ranges with those of the two populations of *P. australe*. Thus the shield dimensions AW, PW, SB, AMB and PSL are significantly larger, while others, such as AP, SP, PDS and most leg dimensions are significantly smaller. Additionally, the medial coxala I of *P. lindsayi* has *c.* 27 digitations, while the medial coxala I of *P. australe* has 15–20 digitations.

Adults: As only two adults of *P. australe* and one of *P. lindsayi* from which larvae have been reared are available, conclusions based on general morphology and metric dimensions need to be more guarded, particularly as one female of *P. australe* was significantly larger than the other. Nevertheless in nearly all cases the dimensions of the adult females of *P. australe* were significantly larger than those for the female of *P. lindsayi*. There are also several differences in the various dimension ratios between the two species (see Tables 2 and 4).

The relations between these adults and other adults allotted to the genus are conjectural. Each of them can be placed in the key to the adults given by Womersley in 1934 (as *Caenothrombium*); the nearest fit being between *P. lindsayi* and *P. nynganense* (Hirst). Even so, the length of tibia I of *P. nynganense* (from Hirst (1928a)) is only 60% of that of *P. lindsayi*, and only 54% or 58% of that of *P. australe*, while the length given of the dorsal idiosomal setae by Womersley (1934) as 65 is significantly shorter than that of *P. lindsayi* (75–80). (See also the Remarks on post-larval *Paratrombium*, below.)

Paratrombium curculionis sp. nov.
(Figs 9, 10A–F)

Material examined

Holotype. Queensland. Wongabel, September 1944, R. N. McCulloch, larva ACB1303, ectoparasitic on a weevil (Coleoptera, Curculionoidea).

Diagnosis of larva

Scutellum with two setae. Posterior claw of tarsus III not reduced. AM setae slender. Medial coxala I with 12–13 digitations. Odontus strongly curved, almost circular. SB<150μm. AW<150μm.

Description of larva (from holotype, slide-mounted)

Colour in life red. Idiosoma 300 long, 205 wide; total length to tip of cheliceral blades 335. Anterior dorsal scutum with smooth borders; anterior border with a slight central concavity (a presumed artefact of mounting); other borders convex except for a weak emargination near the posterolateral angles to accommodate eyes; posterolateral angles rounded. AM setae slender, curved, simple, pointed; AL scutalae stout, tapering, pointed, with a few distal setules; sensillary setae filiform, with a few slender, distal setules. PL scutalae (missing in specimen) arise at PL angles of scutum.

Each eye pair placed near posterolateral border of scutum; corneae circular, anterior 11 across, posterior 9.

Scutellum porose; margins smooth; anterior margin slightly convex; lateral and posterior margins convex; scutalae stout, moderately setulose.

Metric data as in Table 5.

Dorsal idiosomal setae behind scutellum about 20 in number; each seta arises from a small conical papilla; setae stout, blunt-ended, with slender setules in distal half; arranged 2, 2, 6, 4, 4, 2 (pygosomals).

Ventral surface of idiosoma: between coxae II two slender setae, 40 long, pointed, with slender distal setules. Behind coxae III about eight setae, similar to dorsals, 54–60 long, arranged 2, 4 (+ two pygosomals).

Legs of normal stature, short, lengths (including coxae to claws): I 330, II 315, III 335. Leg scobalae pointed, simple, except for a few distal setules. Coxa I stout, triangular, with rounded medial end, carrying a medial pectinate seta 42 long with *c.* 13 slender digitations, arising obliquely, the longest of these arising about 2/3 along coxala (Fig. 10B). Lateral coxala I arises near anterolateral angle of coxa, stout, pointed, curved, setulose, *c.* 55 long. Dorsally above the posterior cornu of the coxal joint a slender, pointed supracoxala, 16 long (Fig. 10D). Urstigma narrow, oval, 31 long by 8 wide, on posterolateral part of coxa I. Coxa II carries two stout, pointed, lightly setulose setae, anterior 64 long, posterior 55. Coxa III with a similar seta 58 long. Scobalar formula (legs I, II, III): Fe 5, 4, 4, Ge 4, 3, 3, Ti 5, 5, 5.

Leg specialized setae: SoGeI.32pd(40), SoGeI.45d(36), VsGeI.76pd(6), SoTiI.47d(25), SoTiI.78ad(24), VsTiI.83pd(6). SoGeII.25d(30), VsGeII.66d(9), SoTiII.31d(30), SoTiII.69d(18). SoTiIII.30p(40).

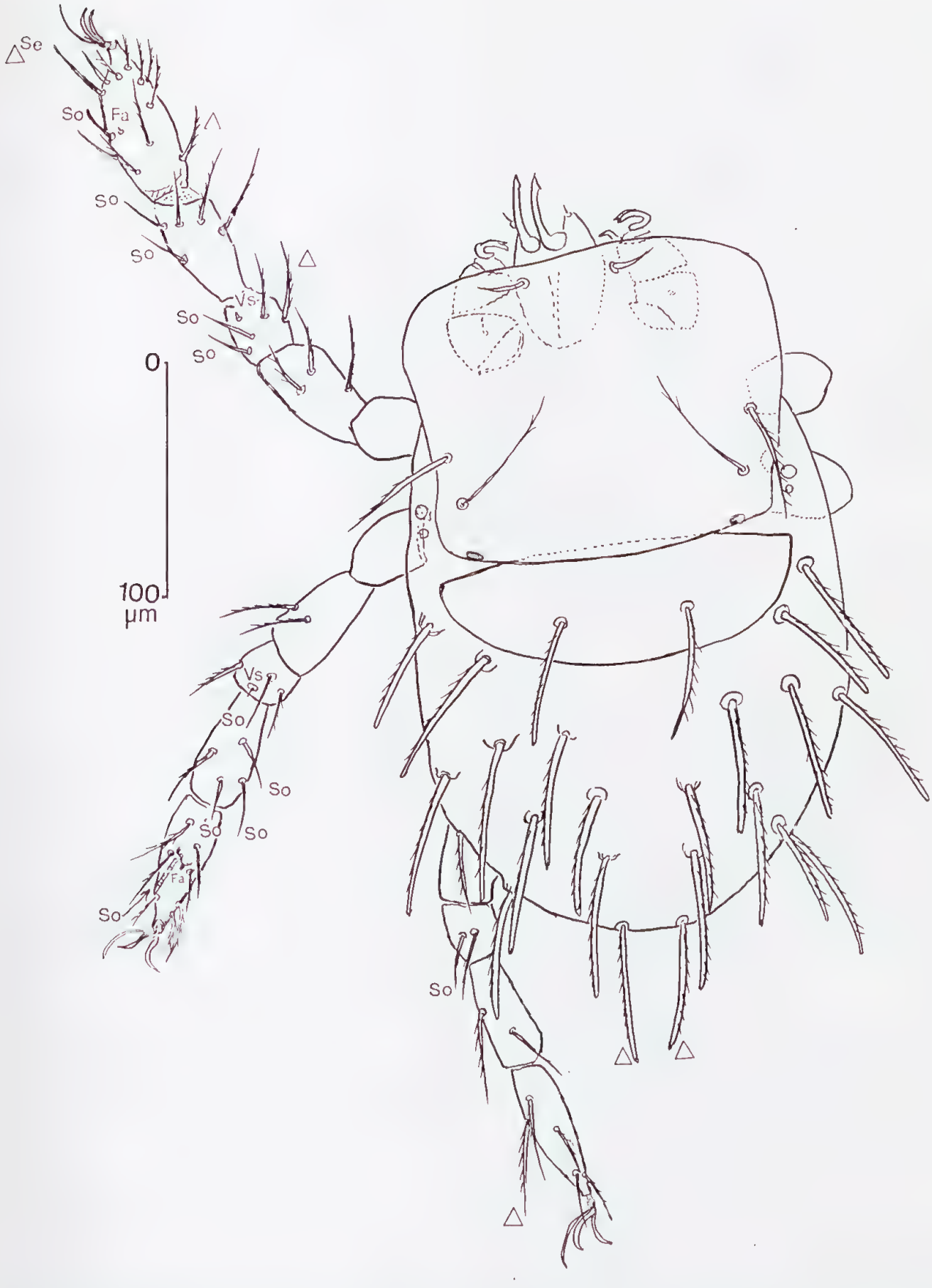

FIGURE 9. *Paratrombium curculionis* sp. nov., larva, holotype. Dorsal view, to standard symbols; on right, legs omitted beyond trochanters.

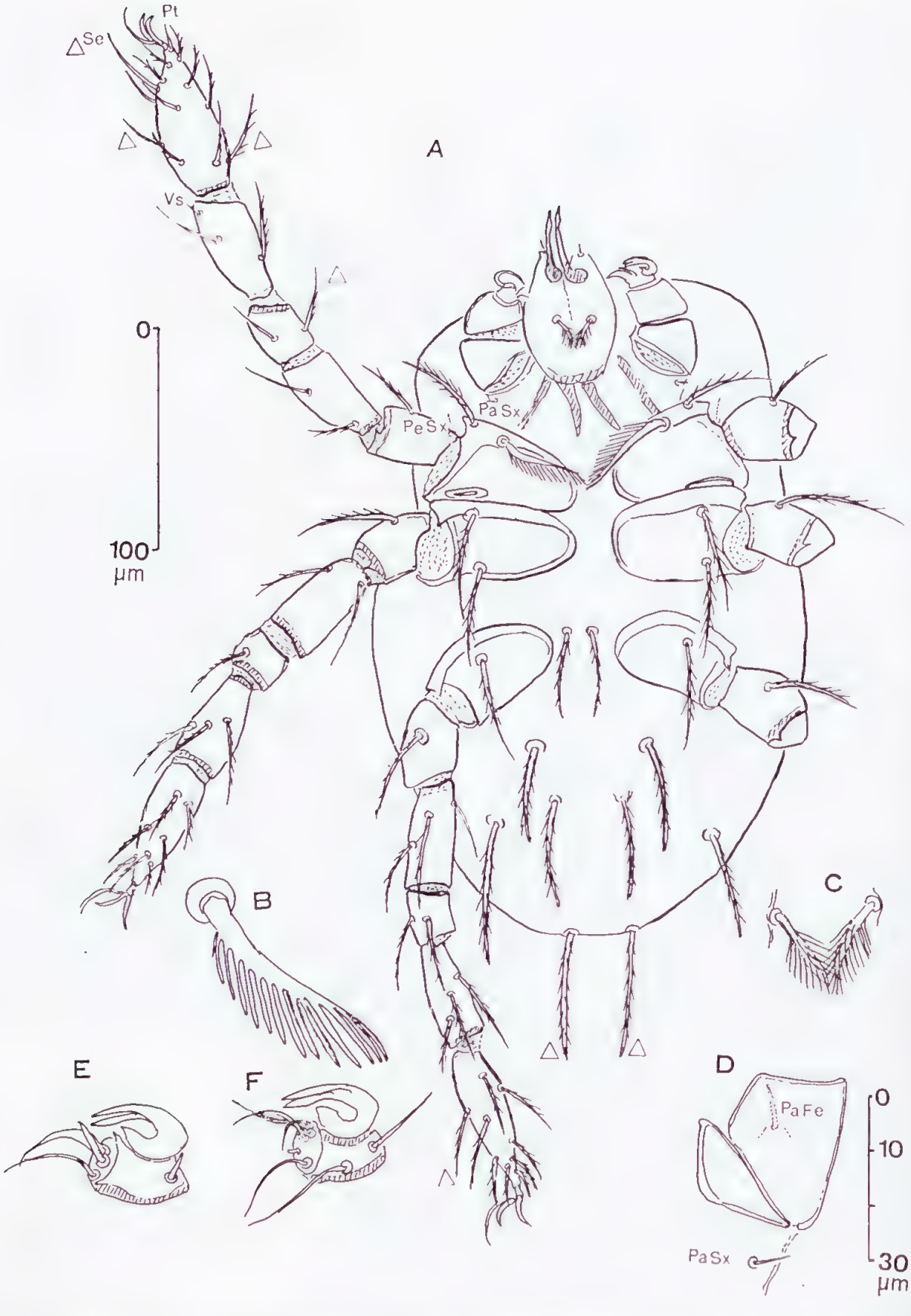

FIGURE 10. *Paratrombium curculionis* sp. nov., larva, holotype. **A**, Ventral view; on right, legs omitted beyond trochanters. **B**, Medial coxala I. **C**, Tritorostral setae. **D**, Ventral aspect of palpal femur and trochanter. **E**, Palpal tibia and tarsus, dorsomedial aspect. **F**, Same, ventrolateral aspect. (To standard symbols; additionally: PaFe palpal femorala, dorsal, shown in stipple in D; PaSx palpal supracoxala; PeSx pedal supracoxala, dorsal, shown in stipple in A.) (A to scale on left; B–F to scale on right.)

TABLE 5. Metric data for holotypes of *Paratrombium curculionis* sp. nov. and *Paratrombium anemone* sp. nov. (larvae)

Character	*Paratrombium curculionis*	*Paratrombium anemone*
LN	15	23
MA	82	87
AW	129	144
PW	110	144
SB	122	123
MSA	68	68
ASB	109	110
PSB	33	45
L	142	155
W	160	167
AP	38	38
SA	23	23
SP	18	21
AM	18	27
AL	42	55
PL	–	73
AMB	39	34
SE	64	–
PLN	28	18
PSL	53	36
PSW	149	160
QW	56	53
QL	62	82
DS	66–68	66–71
MDS	66	66
PDS	68	71
AW/QW	2.30	2.72
PSL/PLN	1.89	2.00
FeI	57	66
GeI	31	36
TiI	57	59
TaI(L)	74	84
TaI(H)	28	25
TiI/GeI	1.84	1.64
FeII	52	62
GeII	26	33
TiII	46	57
TaII(L)	66	69
TaII(H)	23	23
TiII/GeII	1.77	1.73
FeIII	57	66
GeIII	29	34
TiIII	54	68
TaIII(L)	70	76
TaIII(H)	21	19
TiIII/GeIII	1.86	2.00
SA/SP	1.28	1.10
AW/AMB	3.31	4.24
QL/QW	1.11	1.55
PSW/QW	2.66	3.02
MA/AP	2.16	2.29

Tarsus I with SoTaI.47d(20), FaTaI.48ad(3), SeTaI.69d(40), Pt 11 long.Tarsus II with SoTaII.43–.44d(20), FaTaII.48–.40pd(2) Claws of all tarsi smooth, falciform, equal; empodium overreaching claws.

Gnathosoma: chelicerae compact, bases about 55 long by 45 wide (combined); cheliceral digits slender, curved, 39 long, with terminal blade 12 long. Protorostral setae simple, pointed, 7 long. Deutorostrals absent. Tritorostral setae Fig. 10C) curved, 16 long, with brush-like expansion of setules in distal half. Behind posterolateral border of palpal trochanter a slender, simple supracoxala, 8 long. Palpi stout. Palpal femoral seta simple, pointed, 10 long. Palpal tibia (Fig. 10E,F) conical, with three simple, pointed setae; odontus strongly curved, almost forming a circle. Palpal tarsus with seven pointed setae, two deflexed. Palpal supracoxala posterolateral to palpal trochanter, simple, pointed, 8 long.

Etymology

The specific name *curculionis* is a noun in the genitive (Latin), signifying 'of a weevil' (host).

Paratrombium anemone sp. nov.
(Figs 11, 12A–E)

Material examined

Holotype. Papua New Guinea, Babiang, 19.xii.1944, R.V. Southcott, larva ACB267, caught free-living in damp soil. SAM.

Diagnosis of larvae

Scutellum with two setae. Posterior claw of tarsus III not reduced. AM setae slender, not tusk-like. Odontus almost straight, axial to palpal tibia. Tritorostral setae expanded, with several large blunted digitations. Medial coxala I with *c.* 17 digitations.

Description of holotype larva, slide mounted.

Colour in life red

Idiosoma *c.* 300 long by *c.* 200 wide; total length to tip of cheliceral blades *c.* 320.

Anterior dorsal scutum more or less oblong, finely porose, without special markings. Margins smooth; anterior margin with shallow median indentation (possibly an artefact of mounting); shape of lateral margins indeterminate from probable distortion in mounting; posterior margin weakly convex. AM setae slender, simple, pointed. Other scutalae stronger, pointed, simple except for slight terminal setules. Sensillary setae missing in specimen.

FIGURE 11. *Paratrombium anemone* sp. nov., larva, holotype, to standard symbols; legs omitted on left. The specimen is somewhat distorted, and the pattern drawn of post-scutellar doral setae is somewhat interpretative.

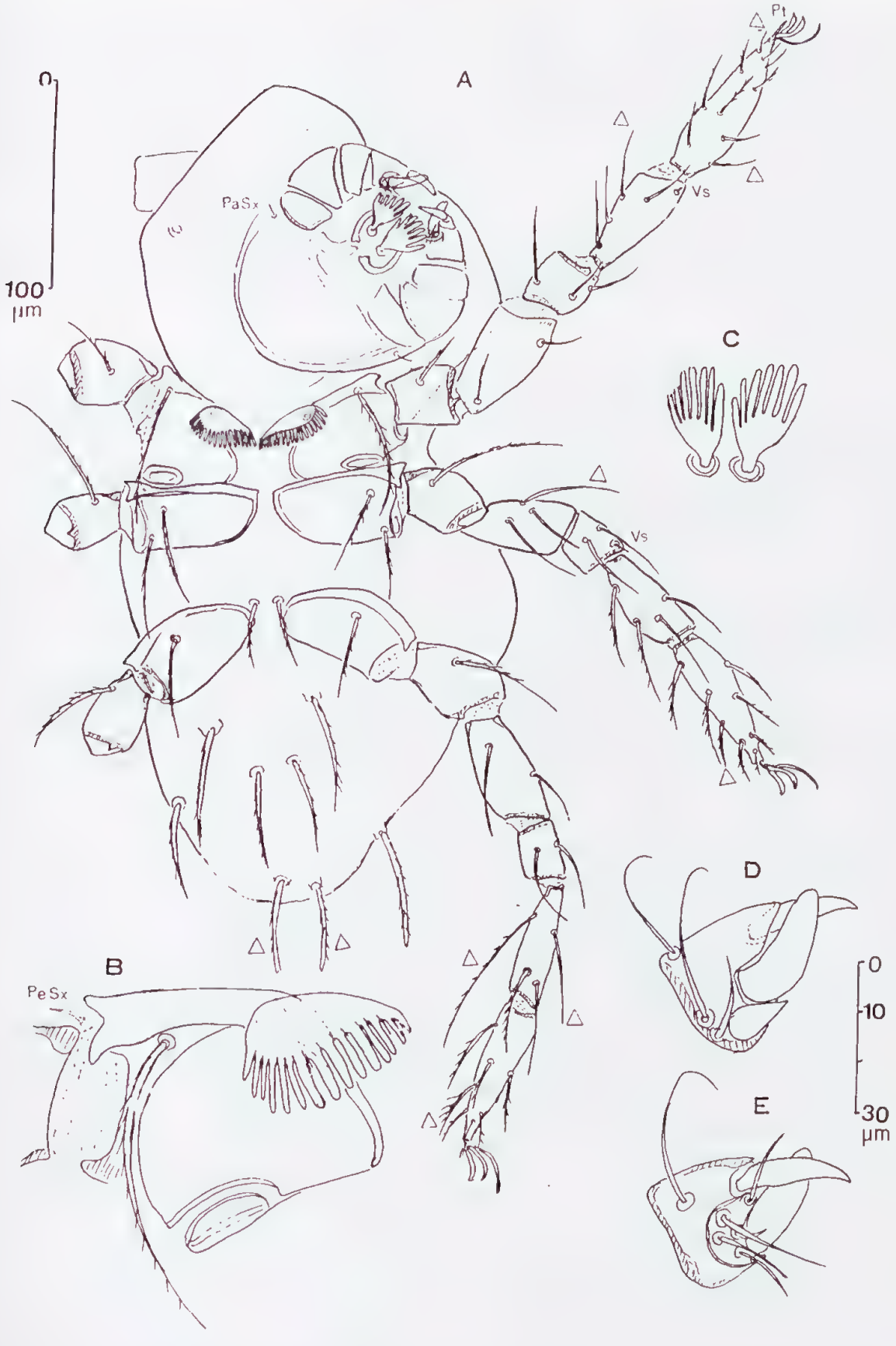

FIGURE 12. *Paratrombium anemone* sp. nov., larva, holotype, to standard symbols. **A**, Ventral view, legs omitted on left. The specimen is somewhat distorted, and the pattern drawn of hysterosomal setae somewhat interpretative; PaSx palpal supracoxala. **B**, Coxa I, ventral aspect, and adjacent structures; PeSx pedal supracoxala (dorsal), shown in stipple. **C**, Tritorostral setae. **D**, Palpal tibia and tarsus, dorsomedial aspect. **E**, Palpal tibia and tarsus, ventrolateral aspect. (A to scale on left; B–E to scale on right.)

Eyes near posterolateral border of scutum, anterior 9 across, posterior 7.

Scutellum porose, narrow, transverse; anterior border linear, anterolateral angles acute, at about 60°; posterior border convex; the two scutalae tapering, pointed, simple except for slight setules in distal half.

Metric data as in Table 5.

Dorsum of idiosoma behind scutellum with *c.* 19 setae, pointed or blunt-pointed, with slender, pointed setules; setae arise from hemispherical papules; precise arrangement uncertain from distortion of specimen.

Ventral surface of idiosoma: between coxae III two slender, pointed, lightly setulose setae, 45 long, arising from papules. Behind coxae III *c.* eight setae, arranged 2, 4 (+ 2 pygosomals); setae similar to dorsals, 70–75 long.

Legs of usual trombidioid larval stature; lengths (including coxae and claws): I 365, II 350, III 375. Coxa I (Fig. 12A) forms a quarter-circle with a projecting anterolateral articular piece. At about the anteromedial position medial coxala I arises, comma-shaped, 38 long by 21 wide, with a row of 16–17 blunt-ended digitations, coming off at about a right angle to the main axis; the digitations are longest at about the middle of the array (Fig. 12B). At about the anterolateral position a strong, pointed lateral coxala I, about 60 long, with fine, pointed setules. Above the anterior cornu of coxa I is a fine, pointed, simple supracoxala, 13 long. Urstigma 21 x 9 present, set in the posterolateral angle of coxa I. Coxa II with two setae, tapering, pointed, with slender setules; anterior seta 60 long, posterior 50. Coxa III with a similar seta, 62 long. Leg scobalae similar, with slender setules; scobalar formula (legs I, II, III): Fe 5, 4, 4, Ge 4, 3, 3, Ti 5, 5, 5.

Leg specialized setae: SoGeI.15d(46), SoGeI.31ad(53), VsGeI.85pd(5), SoTiI.54d(30), SoTiI.70d(22), VsTiI.84pd(7). SoGeII.34d(70), VsGeII.76ad(5), SoTiII.20d(38), SoTiII.53d(53). SoGeIII.25d(75).

Tarsus I with SoTaI.33d(31), FaTaI.45ad(3) SeTaI.68d(47), Pt 14 long. Tarsus II with SoTaII.37d(18), FaTaII.41pd(3). Tarsal claws falciform, smooth, equal over legs I–III; empodium of each tarsus slender, over-reaching the lateral claws.

Gnathosoma: chelicerae compact, bases *c.* 70 long by 50 wide (combined). Protorostral setae not identified. Deutorostrals absent.Tritorostrals (Fig. 12C): each seta expanded to a set of seven round-ended digitations; setae *c.* 27 long Palpal femoral seta slender, pointed, simple, 16 long. Palpal tibia with three simple, pointed setae (or four, anomalously), proximal; also a strong, pointed, undivided odontus, projecting axially. Palpal tarsus with two large, sclerotized ventromedial projections, evidently modified setae; proximal one short and conical, the larger one cucumber-shaped (see Fig. 12D,E), and reaching as far anteriorly to almost the tip of the odontus; also five fine, simple, pointed setae; no solenoidala detected. Palpal supracoxala slender, spiniform, 6 long.

Etytmology

The specific name *anemone* is a noun in apposition, of classical Greek origin, which refers to the zoophyte-like appearances of the tritorostral setae.

Remarks

Paratrombium anemone differs from other described larvae placed in the genus in having spreading, digitate tritorostral setae, and in detailed structure of the palpal tarsus. The latter has two large sclerotized projections, which are presumably modified setae. The more characteristic scobalae of the palpal tarsus appear normal in being slender, simple, pointed, but are without modification into scythe-like forms.

Remarks On Post-Larval *Paratrombium*

Six species of *Paratrombium* have been correlated between larvae and adults by experimental rearing from ova laid by females; two European, two North American and two Australian. These rearings confirm the placing of *Paratrombium* in the Trombidiinae, and allow the corrections of generic placements of earlier authors of Australian adult Trombidiidae. Of those placed in *Caenothrombium* Oudemans, 1927 by Womersley (1934), after the earlier placement of *Caenothrombium miniatum* Womersley, (1934) in *Pollicotrombium* Southcott, 1986 as *P. miniatum* (Womersley) (see Southcott 1986), the following new combinations may be assigned:

Paratrombium album (Womersley, 1934: 204), comb. nov.,
P. augustae (Hirst, 1928b: 1032), comb. nov.,
P. crassum (Hirst, 1928a: 567), comb. nov.,
P. montivagum (Hirst, 1928b: 1027), comb. nov.,
P. nobile (Hirst, 1928b: 1932), comb. nov.,
P. nynganense (Hirst, 1928a; 566), comb. nov.,
P. rainbowi (Hirst, 1928b: 1031), comb. nov.,
P. sericatum (Rainbow, 1906: 158), comb. nov.,

P. splendidum (Hirst, 1928a: 566), comb. nov.,
P. taylori (Hirst, 1928b: 1034), comb. nov.,
P. torridum (Hirst, 1928a: 567), comb. nov.,
P. ventricosum (Hirst, 1928b: 1032), comb. nov.

Some of these species were synonymized by Womersley (1934), with little discussion; however, a key was provided.

One point of interest in adult chaetotaxy is that European *P. megalochirum* (Berlese, 1910) (see Berlese 1912) and *P. divisipili* (Feider, 1950) (q.v.) have thickened dorsal idiosomal setae, while the North American adults described by Newell (1958), and the recorded Australian adults have slender, pointed dorsal idiosomal setae.

Acknowledgments

The work has been supported by the Australian Biological Resources Study.

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A NEW GENUS AND SPECIES OF AUSTRALIAN DYTISCIDAE (COLEOPTERA)

C. H. S. WATTS

Watts C. H. S. 1997. A new genus and species of Australian Dytiscidae (Coleoptera). *Records of the South Australian Museum* 29(2): 121–123.

Sekaliporus kriegi is described from Northern Australia. The new genus and species resembles *Tiporus* Watts and *Antiporus* Sharp (Hydroporinae), but differs from these genera by characters of the humeral angles of the elytra, the postcoxal lines and male protarsi and genitalia.

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Manuscript received 29 January 1996.

Among some *Antiporus* specimens sent to me recently from the Australian National Insect Collection, Canberra were a series of specimens from the Northern Territory that did not fit any known species of *Antiporus* Sharp nor the related *Tiporus* Watts (Watts 1978; 1985; Brancucci 1984). These specimens had the fourth segment of the male protarsi absent (or greatly reduced) and the evenly punctate metatibia characteristic of the *Barrethydrus/Antiporus/Tiporus* group of Hydroporinae. They lacked the pronounced elytral grooving of *Barrethydrus*. The males had the strongly asymmetrical expansion of the protarsi typical of *Tiporus* but they more closely resembled *Antiporus* in the shape of the humeral angle of the elytron and in having four-segmented protarsi. Further study revealed other characters not found in either *Antiporus* or *Tiporus* or in any other Hydroporinae. These specimens are described here as a new genus and species.

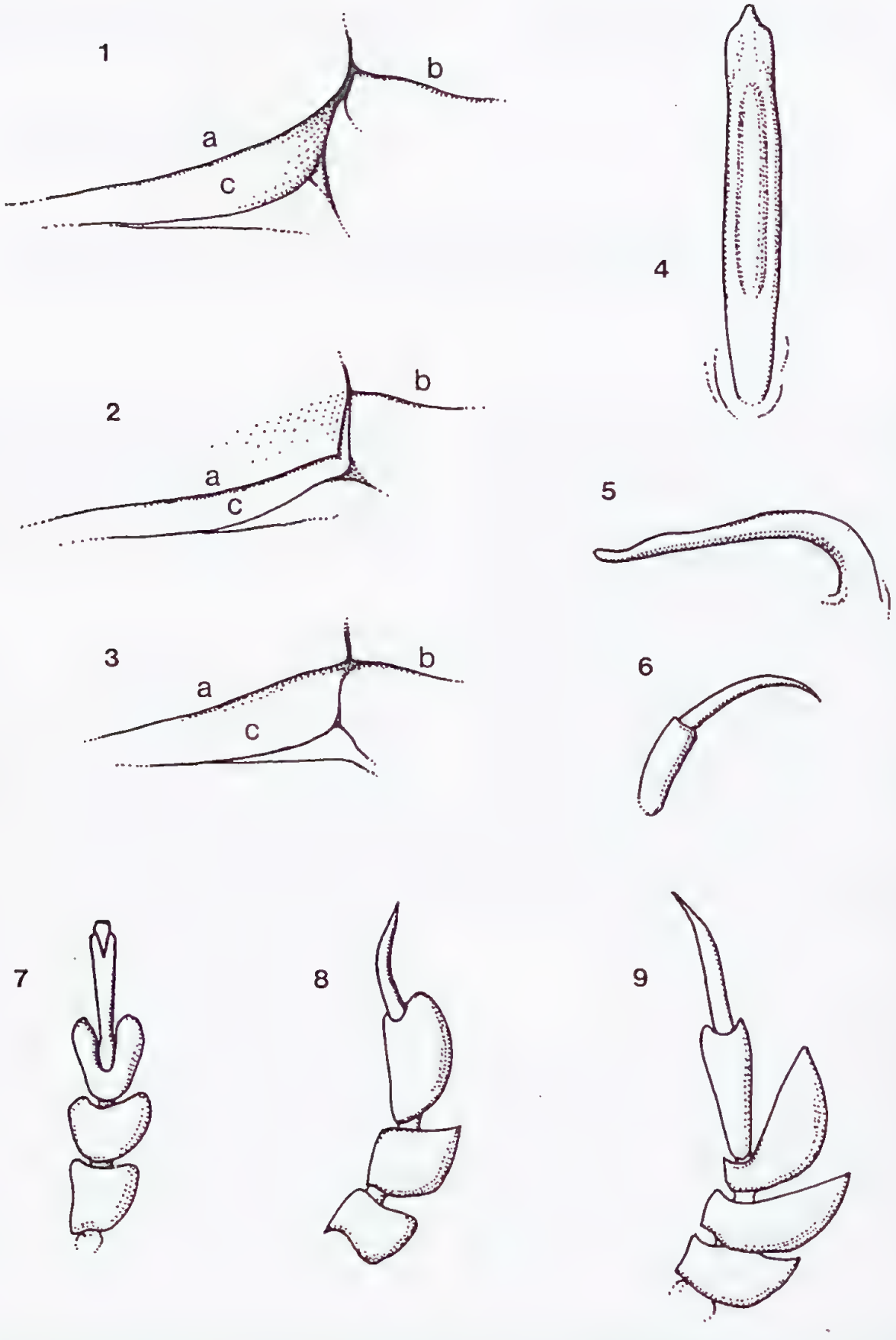
Sekaliporus gen. nov.

A member of the Hydroporinae. Small, oblong oval, convex. Moderate to strong, even punctures throughout. Femora and tibiae punctate. Elytron with wide epipleura, narrowing progressively posteriorly, lateral edge of elytron and lateral edge of pronotum forming nearly continuous straight or slightly sinuate line in combination. Prothoracic process narrow, highly keeled, metacoxal lines well marked or even raised, close together, subparallel for most of their length. Midline of sternites appear somewhat raised or bulbous. Female with pro- and mesotarsi with very small fourth segment, well hidden in lobes of third segment. Male lacks sexual development of legs except for protarsi. Male protarsi with basal three segments markedly asymmetrical, posterior lobes small, anterior lobes greatly expanded, seemingly lacking small fourth segment present in females. Single protarsal claw slender, elongate in only known species. Parameres flat, ribbon like, connect with basal piece of aedeagus only at anterior portion of aedeagus base.

Sekaliporus kriegi sp. nov.
(See Figs 1–9)

Description (number examined, 19)

Length 3.1–3.8 mm. Oblong-oval, convex, elytron extended posteriorly by subapical spine. Nitid, dark red-brown to black, head lighter, pronotum laterally and band across middle diffusely lighter; in many specimens, elytron with one or two subbasal, diffusely lighter patches and one subapical one variable in size, tip usually lighter, appendages a little lighter. Head finely and sharply punctured, punctures less than diameter of eye facets, most separated by more than their diameters, finely reticulate. Pronotum with larger punctures, but still smaller than eye facet, separated by about their diameter on disc, closer laterally, tendency to form longitudinal lines along posterior edge, finely reticulate. Elytra punctured as on pronotum, weak tendency for punctures to form into longitudinal rows anteriorly, denser and stronger apically, virtually lacking reticulation. Elytron weakly margined, margin moderately serrate towards apex, margin produced into well marked broad triangular spine close to apex. Ventral surface strongly and densely rugose - punctate. Prothoracic process narrow, strongly bent in lateral view, strongly keeled, constricted slightly between procoxae, metathorax narrowly raised (viewed ventrally) in middle behind mesocoxae, raised portion grooved in mid-line. Postcoxal lines raised, particularly in anterior



FIGURES 1–9. **1**, Lateral view of humeral angle region of *Antiporus*, a = lateral edge of elytron, b = lateral edge of pronotum, c = epipleura; **2**, Ditto *Tiporus*; **3**, Ditto *Sekaliporus*; **4**, Dorsal view of aedeagus of *S. kriegi*; **5**, Lateral view of aedeagus of *S. kriegi*; **6**, Lateral view of male proclaw of *S. kriegi*; **7**, Ventral view of male right protarsus of *Antiporus femoralis*; **8**, Ventral view of male right protarsus of *Tiporus undecimmaculatus* (Clark); **9**, Ventral view of male right protarsus of *Sekaliporus kriegi*.

third, close together, subparallel, converging slightly in front, diverging slightly behind. Midline of sternites somewhat bulbous.

Male

Protarsi four-segmented, basal three segments strongly asymmetrical, with posterior lobes reduced in size and anterior lobes greatly expanded. First and second segments subequal, third segment twice length of second, anterior lobe nearly as long as narrow un-lobed apical segment. Single claw long and thin, virtually straight except for strong basal curve.

Female

Protarsi five-segmented, three basal segments weakly expanded, segments one and two moderately asymmetrical, third segment weakly asymmetrical; two simple claws.

Distribution

Known only from the type localities in coastal Northern Territory and the Kimberley.

Types

Holotype: Male '12°23'S, 132°56'E, 7km NW by N of Mt Cahill Crossing, East Alligator River, N.T. 9.vi.73, Upton and Feehan', in ANIC.

Paratypes: 1, '12°46'S 132°39'E, 12km NNW of Mt Cahill, N.T. 20.v.73, Matthews & Upton', in ANIC; 3, '12°23'S 132°56'E, 7 km NW by N of Mt Cahill Crossing, East Alligator River, N.T. 9.vi.73 Upton and Feehan', in ANIC; 1, '13°03'S 132°19'E, South Alligator River, N.T. 46km WSW of Mt Cahill. 20.v.73, Matthews & Upton', in ANIC; 3, '12°22'S 133°01'E, 6 km SW by S of Oenpelli, N.T. 30.v.73, E.G. Matthews', in SAMA; 4, same data but at light, 2 in SAMA, 2 in ANIC; 1, 'McArthur River, N.T. 16°39'S 135°51'E 80 km SW of Borroloola, 13.v.73. M.S. Upton', in ANIC; 1, '16°31'S 125°16'E CALM site 25/1 Synnot CK W.A. 17–20 June 1988 T.A. Weir, at light open forest', in ANIC; 2, '12°50'S 132°51'E 16km E by N of Mt Cahill N.T. 13.vi.73 Upton of Feehan', in ANIC; 1, '12° 52'S 132°, S by E Koongarra N.T. 15 km E of Mt Cahill. 12.vi.73 Upton & Feehan', in ANIC; 1, '12°31'S 132°54'E 9km N by E of Mudginbarry HS, N.T. 26.v. 73 at light, Upton & McInnes', in ANIC.

Relationships

Sekaliporus clearly belongs close to *Antiporus* and *Tiporus*. In overall shape, colour and punctation it quite closely resembles *T. josepheni*. It differs from both these genera by having the postcoxal lines very close together and almost parallel and in the shape of the humeral angle of the elytron. In *Sekaliporus* the epipleuron is sharply bent inwards to accommodate the profemur to the same extent as in *Tiporus* but the edge of the elytron is not also bent sharply as in *Tiporus* and to a lesser extent in *Antiporus*, but remains in the same line as the edge of the pronotum. The characters of the male also set *Sekaliporus* apart. Except for the protarsi, the legs of the males are simple in the only known species whereas in all known species of *Tiporus* and all but one *Antiporus*, the legs of the male are modified in some way. The male protarsi are unique. All three basal segments are grossly asymmetrically expanded, as in *Tiporus* but not *Antiporus*. The protarsi are four segmented as in *Antiporus*, in contrast to *Tiporus* which has only three segments and lacks the slender apical segment [the single claw arises from the third segment]. The parameres in both *Tiporus* and *Antiporus* are generally shortish and broad, often almost bulbous. In *Sekaliporus* they are noticeably more elongate and ribbon like and appear to be differently attached to the basal piece although this will need to be confirmed by careful dissection when more specimens become available.

Acknowledgments

I would like to thank Mr T. A. Weir of the Australian National Insect Collection for sending me these specimens, Mr Rob Gutheridge for drawing the illustrations and Mrs Vicki Wade and Ms Robyn Cherrington for typing the manuscript.

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THE ABORIGINAL COSMIC LANDSCAPE OF SOUTHERN SOUTH AUSTRALIA

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CLARKE, P. A. 1997. The Aboriginal Cosmic Landscape of Southern South Australia. *Records of the South Australian Museum* 29(2): 125–145.

This paper provides an overview of recorded accounts of Aboriginal beliefs from southern South Australia concerning the cosmos. This study is restricted to discussing a pre-European system of beliefs. It further develops concepts about Aboriginal relationships to space as discussed by Clarke (1991a). Star maps are provided for the Adelaide and Lower Murray areas.

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Introduction

In the mythologies recorded by the ethnographic sources for southern South Australia, there is frequent mention of Aboriginal beliefs concerning the origin of various cosmic bodies and their relationships to ancestral beings, both in the heavens and on earth. Many of the ancestral spirits that were considered to have been involved in the creation of the world, ended up in the sky. The present paper assembles information on the heavens and discusses how it was organised in the pre-European systems of belief. Although atmospheric properties, such as clouds, wind, rain, etc., are also clearly related to Aboriginal beliefs about the regions above them, this paper focuses chiefly on astronomical traditions.

The data presented in this paper is historical, recorded from Aboriginal people who had lived in the southern districts prior to and during the early phases of European colonisation in South Australia. The sources provide a fragmentary record from observers who were generally not privy to insider views of the indigenous cultures. Much of the material available consists of the observations from Europeans chiefly concerned with the setting up of colonial social structures, such as the legal system and Aboriginal welfare. Teichelmann, Schurmann, and Meyer were German missionaries who actively recorded the culture of their intended Aboriginal converts. Their reliability as sources comes through personal knowledge of the languages involved. Nevertheless, some caution is necessary because the missionaries were looking for religious ideas to assist in translating Christian terms. Their publications, which were published between 1840 and 1846, were essentially studies of Aboriginal language and religion (Teichelmann & Schurmann 1840; Teichelmann 1841; Meyer 1843; 1846; Schurmann 1844; 1846). The ethnographic dominance of these recorders was such that other sources for southern South Australia, such as Gell (1842), Wilhelmi (1860), and Taplin (Journals; 1874; 1879) acknowledged them as major sources of primary data. The main account provided by Wyatt (1879) stemmed in part from material he gathered while preparing a report in 1838 concerning whether Aboriginal religion provided for beliefs in 'God' and an afterlife, upon which an oath in a court of law could be based.[1] The ethnography of Moorhouse (1843; 1846) was compiled by him in his official capacity of Aboriginal Protector. Although all ethnographic accounts were written by men, in the case of the missionary, Taplin, there is evidence showing that he incorporated the observations and views of his wife.[2] These observers had a practical interest in Aboriginal religion and traditions, in spite of the fact that their records were compiled before the development of anthropological theory.

During the twentieth century, much ethnographic data from southern South Australia was collected and published by Tindale (1935; 1936; 1937; 1938; 1939; 1940; 1941; 1974; 1987; Tindale & Mountford 1936; Tindale & Pretty 1980), the Curator of Anthropology at the South Australian Museum.[3] His data chiefly came from elderly Aboriginal informants he interviewed from the late 1920s onwards. His Aboriginal sources included John Wilson ('Sustie'), Reuben Walker, Amelia Savage ('Ivaritji'), Henry Mason

('Mengoan'), Robert ('Joe') Mason, Mary ('Grannie') Unaipon ('Ngunaiponi'), and Clarence ('Clarrie') Long ('Milerum'). The Aboriginal people who worked with the social anthropologists, Ronald and Catherine Berndt (Berndt 1940; Berndt & Berndt 1993), included Barney Warrior ('Waria'), Albert Karloan ('Karlonie'), Mark Wilson ('Thralrum'), and Margaret ('Pinkie') Mack. The mythology upon which the folklorist, Smith (1930), based his Aboriginal stories was primarily gathered by his Ngarrindjeri informant, David Unaipon.[4] As a body of literature these twentieth century ethnographic sources are essentially attempts to record a pre-European culture as it would have been experienced to the generations preceding that of their informants. In contrast to studies that described a living situation, these are studies of 'memory culture' (Berndt 1974: 22, 25; Tonkinson in Berndt & Berndt 1993: xix). A more

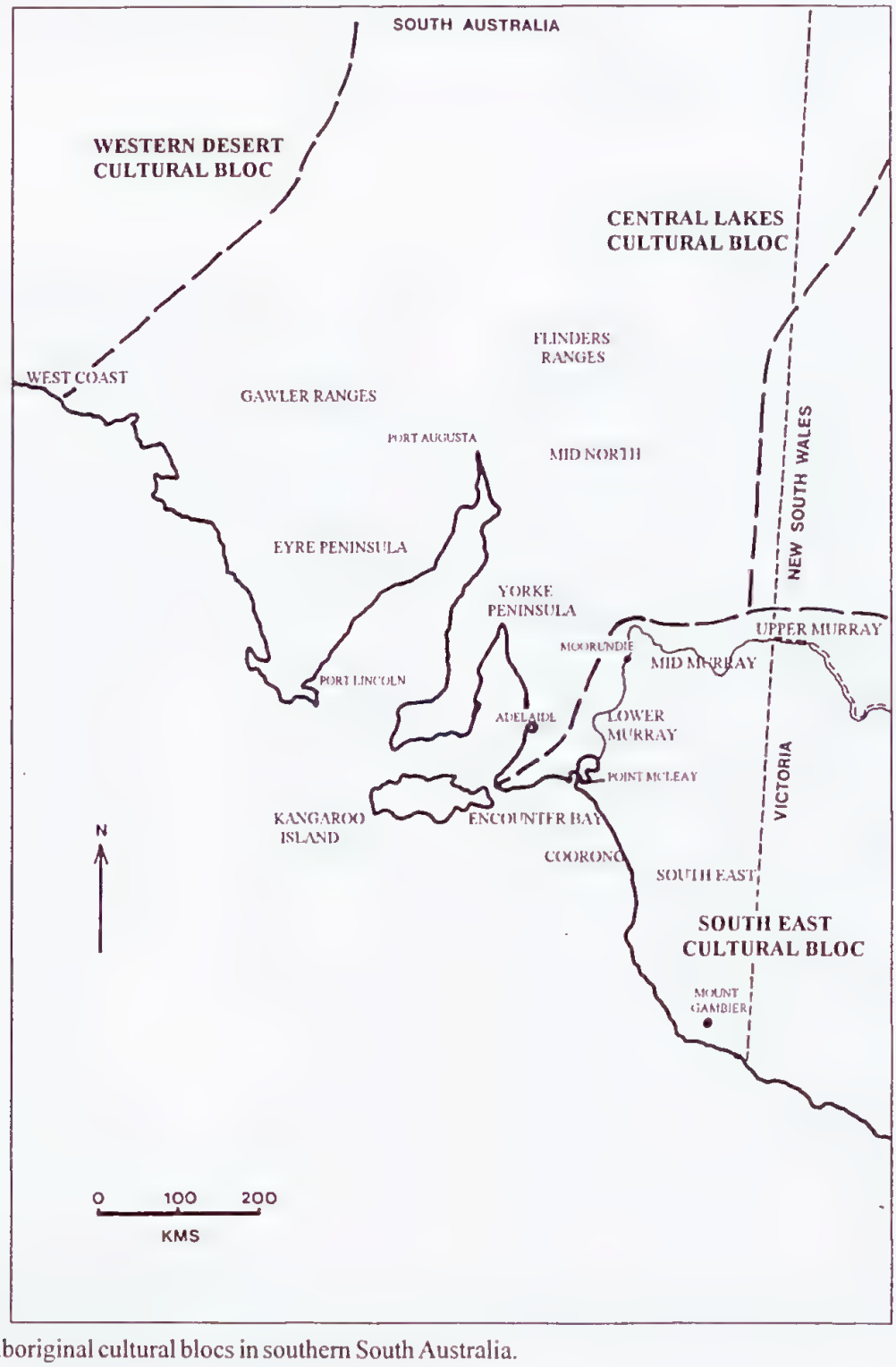

FIGURE 1. Aboriginal cultural blocs in southern South Australia.

detailed analysis of the chief historical sources used in this paper is given elsewhere (Clarke 1994: 63–81,417–425; Clarke 1995: 145,146). The present article is part of a larger study of Aboriginal relationships with the landscape of southern South Australia (Clarke 1990; 1991a; 1991b; 1994; 1995), which combine historical and ethnographic sources with data gathered from contemporary fieldwork. The language and cultural groups identified in the literature are mapped by Schmidt (1919) and Tindale (1940; 1974). The geographical and broad cultural regions used in this paper are identified in Figure 1.

European accounts of Aboriginal relationships to space have tended to describe territoriality over two-dimensional space, rendered as 'tribes' on maps (for example Tindale 1940, 1974). Nevertheless, from ethnographies across Australia, it is clear that Aboriginal people considered that there were other realms within the perceived cultural landscape in addition to their own terrestrial regions, to which they could travel in spirit form.[5] Such regions are the Skyworld and the Underworld. The latter is also sometimes recorded as the 'Land to the West'.[6] It appears that with the fragmentation of the spirit after death, both regions could be the abode of the spirit to the same Aboriginal group.[7] These landscape perceptions are also common concepts throughout the Oceanic region (Luquet 1968: 451,452). Such *places* are defined as psychic landscapes in this paper because they are not tangible according to a contemporary Western definition of landscape, which is concerned with topographical features. They are nevertheless important inclusions to the mapping of the total cultural landscape of the Aboriginal people.

The perceived existence of the Heavens as an analogue of the terrestrial landscape is common across Australia. This Skyworld was considered to be a region which, to some extent, obeyed the same laws as those of terrestrial regions.[8] Teichelmann stated that the Adelaide Aboriginal people:

> consider the firmament [Heavens] with its bodies as a land similar to what they are living upon... It is their opinion that all the celestial bodies were formerly living upon earth, partly as animals, partly as men, and that they left this lower region to exchange for the higher one. Therefore all the names which apply to the beings on earth they apply to the celestial bodies, and believe themselves to be obnoxious to their influence, and ascribe to them mal-formation of the body, and other accidents (Teichelmann 1841: 8).[9]

In the Adelaide area, the 'sky' was recorded as 'Ngaiera' (Teichelmann & Schurmann 1840, pt 2: 29).[10] In the Parnkalla language of eastern Eyre Peninsula, it was similarly termed 'Naieri' (Schurmann 1844, vol.2: 37).[11]

Accounts that illustrate the connectedness between the Skyworld and the terrestrial landscape exist for other parts of southern South Australia. In the Mid Murray area, Eyre noted:

> One old native informed me, that all blacks, when dead, go up to the clouds, where they have plenty to eat and drink; fish, birds, and game of all kinds, with weapons and implements to take them. He then told me, that occasionally individuals had been up to the clouds, and had come back, but that such instances were very rare; his own mother, he said, had been one of the favoured few. Some one from above had let down a rope, and hauled her up by it; she remained one night, and on her return, gave a description of what she had seen in a chant, or song, which she sung for me, but of the meaning of which I could make out nothing (Eyre 1845, vol.2: 367).

It is possible that beliefs such as these reflect some influence from Christianity, perhaps gained from missionaries whom Murray River people met when receiving rations at the Native Location in Adelaide or through the education of their children at the Native School.[12] In the Lower Murray area, Taplin recorded 'Talkothere says that a little while ago he dreamed that he was sick and a line came down from heaven and fastened on his foot to pull him up there and he took out his knife and cut it and so escaped (Journals 22 April 1863)'. The connection between the spirit and the Skyworld is broad, involving both ends of an individual's life cycle. For instance, Pinkie Mack, a Yaraldi woman of the Lower Murray, claimed that before birth 'children are said to be little, flying about in the air, dropped out of a bag and they could be caught' (Harvey 1939). Presumably, the sky was perceived as being spatially very close to people living in the terrestrial region. The body of knowledge about the cosmos was not divorced from everyday living.

The Skyworld was perceived as a place where greater knowledge could be attained (Elkin 1977: 53,75,76,81,87,90). For example, in the Adelaide area, initiates were ritually taken to the celestial region in order to gain sacred knowledge (Teichelmann & Schurmann 1840, vol.2: 13,22). In the above quotation from Eyre, an Aboriginal woman reportedly learned a new song during a visit to the Skyworld. Similarly, in the Lower South East of South Australia, a healer reportedly gained knowledge through crossing into the

Heavens by climbing a tree (Smith 1880: 30). In south-western Victoria, Aboriginal 'doctors' and 'sorcerers' frequently claimed to have visited the Skyworld (Dawson 1881: 57,58). The perceived existence of this psychic landscape therefore had a significant role in the cultural organisation of people and space.

The Heavens were known to Lower Murray people as Waiirri.[13] The Lower Murray people believed that they would all go to Waiirri after death (Taplin 1874 [1879: 18,19]). The Ramindjeri people had a term, 'Ngranggerakkauwull-urmi', which reportedly meant the 'arch of the heavens' (Meyer 1843: 88). The Booandik people from the Lower South East possessed the phrase 'kan-murn-a-moorn-o-noong', which apparently translated as 'up in the clouds' (Smith 1880: 134). They also called the clouds, 'moorn', which was apparently the same term for skin (Smith 1880: 129). In Gundidjmara region of south-western Victoria, the 'smaller stars' together formed 'star earth' (Dawson 1881: 99). In Central Australia, 'tribal' or linguistic boundaries are reflected in the cosmic landscape (Maegraith 1932: 20,26). The Aboriginal ethnography of southern South Australia demonstrates the widespread perception that the sky was a landscape, similar to that of the terrestrial plane.

It appears that the sky was considered to begin at the height of a tree or at most a hill. One ethnographer claimed that the 'Lower Murray tribe do not climb trees'.[14] This may possibly have been through a general fear of entering the Skyworld. If so, then presumably this only applied to upper sections of the tree, as Aboriginal people in better wooded areas still climbed trees to catch possums, collect honey, and cut bark for canoes. In the Lower Murray region, particular large trees and big sand dunes that were considered to reach the clouds and which attracted lightning strikes, were regarded as malevolent (J. C. Harwood, cited Tindale 1930–52: 193,194).[15] In the Waiyungari myth of the Lower Murray, the Skyworld was reached by the throw of a spear (Tindale 1935). In the Adelaide area, a Monana spirit used a similar method to attain access to the Skyworld.

> [He] was one day throwing large spears in various directions, east, west, north, south; when, having thrown one upwards, it did not return to earth. He threw another, and another, and so continued throwing; each spear sticking fast to the former one until they reached the ground, and he climbed up by them to the sky, where he has ever since remained (Wyatt 1879: 166).[16]

Monana was considered to be a mortal who had accomplished immortality. In the southern Eyre Peninsula district, Aboriginal people believed that thunder was caused by the spirit creator, Pulyallana, having fits of rage and storming about the clouds (Schurmann 1846 [1987: 243]; Wilhelmi 1860).[17] Lightning was reportedly produced when he jerked open his legs. The Skyworld was perceived by Aboriginal people of southern South Australia as a part of the landscape that was not beyond their physical reach.

The amount of cosmological knowledge possessed by the Aboriginal people of southern South Australia must have been considerable. Teichelmann recorded that with 'the exaltation of almost every constellation they give the history of the attending circumstances, which the reasons of their present movements explain' (Teichelmann 1841: 9). The cosmos is important in the mythology associated with the ancestral creative period, called in Aboriginal English the 'Dreamtime'.[18] However, there appears to have been many layers to this body of knowledge. Teichelmann wrote:

> The opinions which the Aborigines of South Australia entertain about the visible world are limitedly known, as they carefully conceal them from Europeans, and even their own males are only at a certain age initiated into the knowledge of them (Teichelmann 1841: 8).

Indeed, the informants of Schurmann guarded their secrets so much that he was only told about the cosmology under the condition that he would not tell another Aboriginal person.[19] The cosmic bodies were rich with meaning. This is illustrated in an account by Giles, recorded from an Aboriginal man named Billy Poole from the Lake Albert area of the Lower Murray.

> When around the camp fire at night he [Billy Poole] told me the names of stars, and, moreover, of constellations. He pointed out one group as an old man kangaroo with his arm broken; another group was a turkey sitting on her eggs, the eggs being our constellation Pleiades, another a Toolicher, a small and very prettily marked kangaroo peculiar to the district; another an emu and so on.[20]

Another record for the Lower Murray lists celestial bodies such as Nunganari (stingray), Pindjali (emu), and Prolggi (brolga) (Berndt & Berndt 1993: 164, Fig.25).[21] The cosmic landscape was therefore, to these Aboriginal people, populated with animal species that also occurred in their terrestrial landscape of the Murray River.

Aboriginal kinship patterns were also reflected in the sky (Fig.2,3). For instance, Lower Murray people formerly believed that some of the stars were deceased ancestors, such as Ngurunderi, Waiyungari, Nepeli, Manchingga, and their families, who were now living in Waiirri.[22] This is consistent with the relatively short lineages recalled by them, with their totemic ancestors ending up as stars. Meyer (1846 [1879: 201]) recorded the Ramindjeri belief that 'The stars were formerly men, and leave their huts in the evening, to go through the same employments which they did while on earth'. In the Adelaide region, Monaincherloo (= Munaintyerlo or Monaincherloo) was described as the 'highest creature'.[23] He created all things in the visible world. No one made or created him. According to one account he had always been in the Heavens above, although others state that he did live on the lower landscape once.[24] Another ancestral being significant to Adelaide people was Teendo Yerle, literally 'Sun-father' (= Tindoyerli & Tindojerlimejo [lit. 'Sun-father man']).[25] The name of Teendo Yerle suggests a father relationship with the Sun. Teendo Yerle had several wives, probably planets, who were perceived as very good. However, he also had a pair of sisters who were said to be 'long', probably comets, and evil. He had power over life and death. The Skyworld landscape was therefore humanised, to a similar extent to the lower landscape.

The influence of the stars was not always considered benign. For example, Eyre (1845, vol.2: 361) stated that Aboriginal people in the Mid Murray area considered 'Malformations of the body are attributed to the influence of the stars ... in consequence of forbidden food being eaten.' Teichelmann (1841: 9) recorded a similar belief from the Adelaide people. Similarly, the Lower Murray people believed that a being named Karungpe, who lived in Waiirri, would come down to the campfires at night, scattering the embers and causing death (Taplin Journals 27 June 1861). Southern Aboriginal people generally considered that the beings who had become stars still had some influence over earthly events.

Knowledge of the cosmos appears to have existed in the same varied manner of other bodies of mythological-based beliefs (see Clarke 1991a; Clarke 1995). In south-western Victoria, Dawson (1881: 98,99) stated:

> Although the knowledge of the heavenly bodies possessed by the natives may not entitle it to be dignified by the name of astronomical science, it greatly exceeds that of most white people. Of such importance is a knowledge of the stars to the aborigines in their night journeys, and of their positions denoting the particular seasons of the year, that astronomy is considered one of their principal branches of education. Among the tribes between the rivers Leigh and Glenelg, it is taught by men selected for their intelligence and information.

With the identification of 'Dreaming' ancestors in the Skyworld, it is clear that the cosmic bodies were referable as markers of 'Dreamtime' events in the same manner as terrestrial topographic features of the landscape. It follows that like the accounts of the 'Dreaming', we should expect the associated mythology to vary in detail even within a cultural area, although the basic structure remained the same.

Across Australia, many Aboriginal groups considered the Heavens or Skyworld to be where their spirit, or a part of it, travelled to after death (Elkin 1977; Berndt & Berndt 1993 [1981]). The accounts from the Lower Murray of the Sun and the Moon, mention that after setting they passed through the 'dwelling-places of the dead'. Taplin (Journals 12 April 1862) records that Aboriginal people in the Lower Murray had a belief that the spirits of the dead descended into the ocean at a place beyond Kangaroo Island. Nevertheless, the Skyworld was also a destination for the souls of dead people. It is therefore likely that the early Lower Murray people believed in the fragmentation of the soul in the afterlife, which conforms to the beliefs of other southern Aboriginal groups.[26] The movements of the Dreaming ancestors in the Lower Murray also shows this division. For instance, Ngurunderi was perceived as going to live in the west after creating the Lower Murray (Clarke 1995). The west here was equated with the Underworld, where the Sun passed through after setting in the western horizon. However, Ngurunderi was also thought to be present in the Skyworld. From here he directed the movement of souls, termed 'pangari' by Lower Murray people (Meyer 1843: 90; Taplin 1879: 138). Angas (1847: 97) records that 'after death the spirit wanders in the dark for some time, until it finds a string when ... Oorundoo [Ngurunderi] pulls it up from the earth.' It is possible that the introduction of Christianity influenced south-eastern Australian Aboriginal beliefs about spirit ancestors who went up into the Sky.[27] Other Dreaming ancestors became divided in a different way. For instance, in the southern Fleurieu Peninsula area, the body of the Tjirbruki ancestral creator became a stone, and his spirit

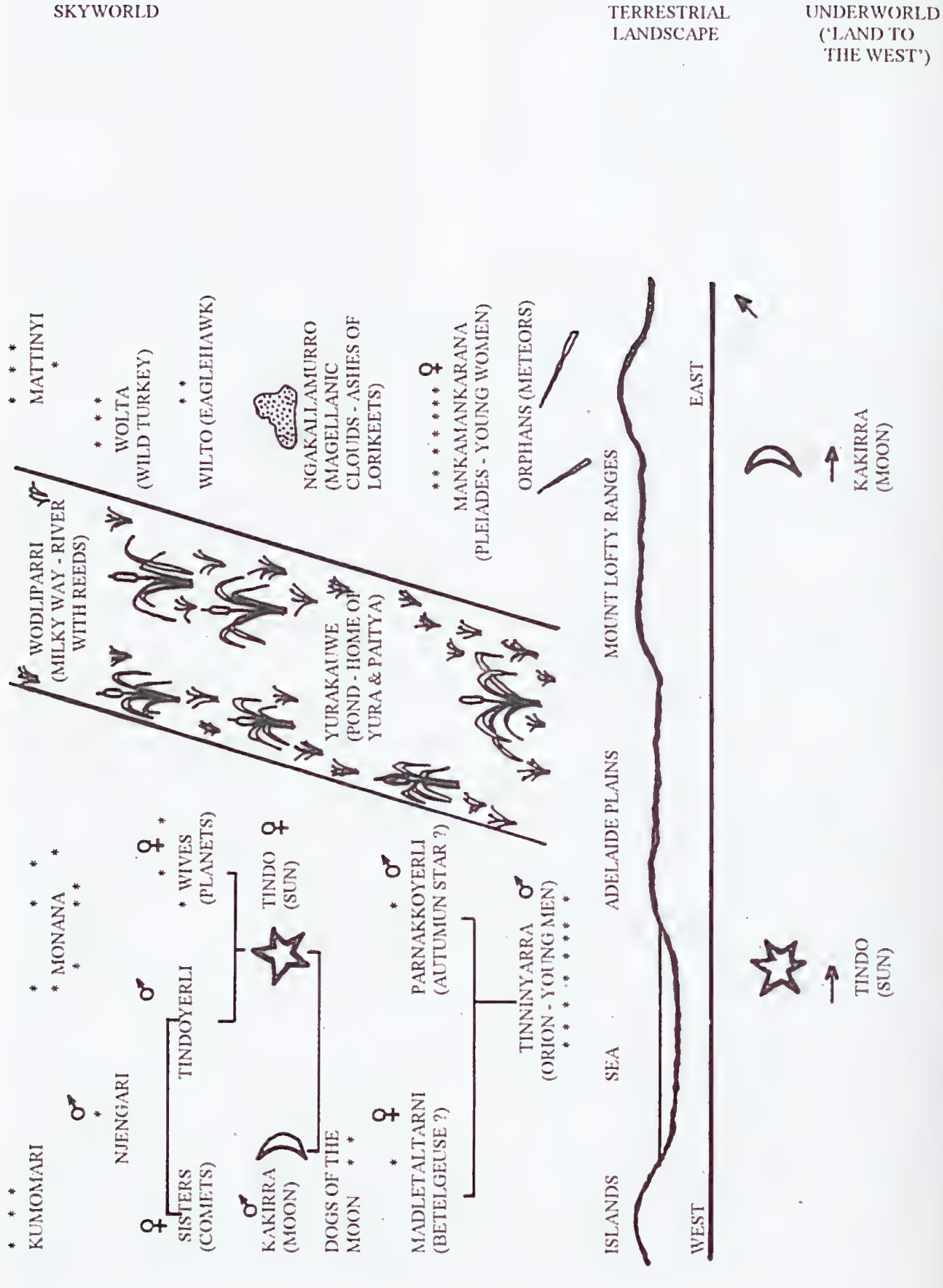

FIGURE 2. The Aboriginal cosmic landscape of the Adelaide area.

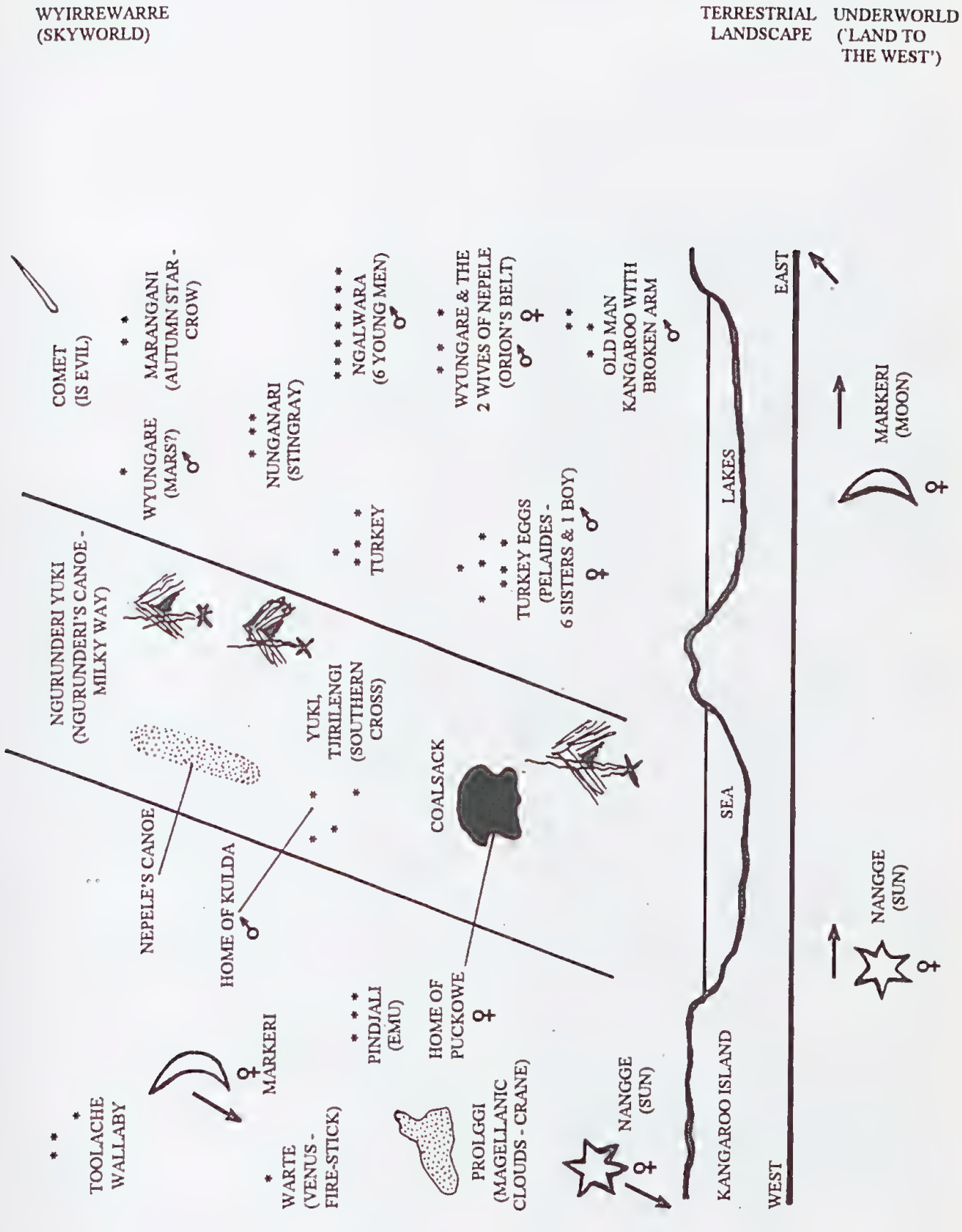

FIGURE 3. The Aboriginal cosmic landscape of the Lower Murray.

was transformed into a blue crane (Smith 1930: 340,341).[28] With Aboriginal beliefs in the spirit, it is clear that the total landscape defined both the living and the dead.

Although the original traditions were rich, the cultural information garnered from the historical literature is fragmentary and sometimes contradictory. At least some of the variations in beliefs about the cosmos may have resulted from the differences between insider and outsider knowledge. In other cases, the differences may reflect regional and socio–political influences. A few of the records also indicate an error by the recorder. In some cases, the combinations of stars which form a constellation for Europeans, differ from those that other cultural groups have chosen. Therefore, the translator may not be accurately recording the identity of some of the constellations as perceived by Aboriginal people. Elsewhere in Aboriginal Australia, colour was important in determining the identity of various celestial bodies (Maegraith 1932: 25). With these restraints in mind, an outline will now be provided of the Aboriginal cosmology of southern South Australia.

Stars (Generally)

In the Adelaide area, stars as a class were called 'purli'.[29] Similar terms for other areas include 'purdli' or 'purli' in the Parnkalla language of eastern Eyre Peninsula (Schurmann 1844, vol.2: 61), 'buli' in Narangga from Yorke Peninsula (Black 1920: 86), 'purtli' or 'purlali' in Nukunu of the southern Flinders Ranges (Hercus 1992: 27), 'budli' in Ngadjuri of the Mid North of South Australia, 'buudli' in Wailpi of the central Flinders Ranges (Berndt & Vogelsang 1941: 9), and 'pedli' in the Ngaiawang language of the Mid Murray area (Moorhouse 1843 [1935: 34]).[30] In the Lower Murray area, stars were collectively called 'tulde' by Ramindjeri people at Encounter Bay (Meyer 1843: 101), 'tuldar' in the Ngarrindjeri language of the Lower Lakes area (Taplin 1879: 138), and 'thildi' in the southern Coorong district (Wells 1852–1855: 112). In the South East, the star terms are 'troot' in the Tatiara language (Haynes & Curr, in Curr 1886, vol.3: 457,459), and 'boongil' in Booandik from Mount Gambier (Stewart, in Curr 1886, vol.3: 465).

Moon

In Adelaide mythology, the first celestial body to leave the lower landscape was the Moon. Here, the Moon, known as Kakirra, was considered to be male.[31] He persuaded all the rest to follow so that he might have companions. The Moon kept a great number of dogs for hunting, who were seen as stars. They had two heads but no tail. He was generally benevolent and had no particular influence on human life. Here, the Moon was called Kakirramunto when in full phase. In Nukunu mythology from the southern Flinders Ranges, there was a related account of how the Moon entered the Skyworld:

> The Moon [Pira] was greedy with meat and would not share it with others, crowd decided to get rid of him, coaxed him to climb a tree and get grubs, coaxed him up higher and higher until they could hardly see him. They cut the tree down, and the Moon hung up in the sky. Moon said 'I'll give the light for people who walk at night. I'll die then come to life again (Mountford, cited Hercus 1992: 16,17).

In the Mid Murray region, Aboriginal people used the term, 'Kakere', or variations of it for the Moon.[32] One group of people was known to Murray River as the 'Moon men' (Tindale 1953: 17,31,32). Their territory, north of Morgan, was the 'country of the Moon'. A 'tribe' to the east of the Adelaide region apparently called the Moon, Piki, although this term also appeared in an example of a sentence spoken by an Adelaide person (Teichelmann & Schurmann 1840, vol.2: 38; Teichelmann, 1857). Near the confluence of the Darling and Murray Rivers, the Maraura called the Moon, 'Patjira' (Tindale 1930–52: 251). In the Eyre Peninsula and West Coast districts the Moon was considered to be the spirit being, Piira, who was once a man who chased the Seven Sisters (Pleiades) across the landscape (Tindale 1928: 21).[33]

To the Lower Murray people, the Moon was called Markeri, or variations of it.[34] In contrast to the Adelaide area, here the Moon was female. Meyer stated that the Ramindjeri people believed that, like the Sun, the Moon spends its time away from the sight of the terrestrial landscape with men of the 'dwelling-places of the dead' (= Underworld). He recorded:

> The Moon is ... a woman, and not particularly chaste. She stays a long time with the men, and from the effects of her intercourse with them, she becomes very thin, and wastes away to a mere skeleton. When in this state, Nurrunduri [Ngurunderi] orders her to be driven away. She flies, and is secreted for sometime, but is employed all the time in seeking roots which are so nourishing that in a short time she appears again, and fills out and becomes fat rapidly (Meyer 1846 [1879: 200,201]).

This belief explains how the Moon's appearance is not timed to the Sun, and also accounts for the phases of the lunar month.[35] The Yaraldi people of Lake Alexandrina had similar traditions to the Ramindjeri concerning the Moon (Berndt & Berndt 1993: 131,232,233,445). They also believed that the lunar cycle had an effect upon female menstruation (Berndt & Berndt 1993: 156). Further up the Murray River, into northern Victoria, the Moon was considered to be female, as it was in the Lower Murray (Smyth 1878, vol.1: 431).

The Potaruwutj people of Keilira in the South East called the Moon, Mitjan, and considered it to be a male of the native cat (*Dasyurus*) totem.[36] It was believed that he attempted to steal the wife of another being before being driven away. He wandered about, sometimes well fed, at other times starving. This observation explains the phases of the Moon. According to Tindale, the name, Mitjan, or a variation of it, was used by groups ranging to the north-east, as far away as the Wati Wati people of Swan Hill in Victoria.[37] The term, Jern (pronounced Yern?) for Moon occurred in groups to the east of the Potaruwutj. Similarly, Tu:ngum was used in the Lower South East of South Australia and in the adjacent parts of Victoria.[38] Here, the Moon was also considered to be masculine (Dawson 1881: 99).

In southern South Australia, the appearance of the Moon was used as a measure of time. In the southern Coorong district, the number of full Moons was sometimes used to record the age of children, if less than a year old (Wells 1852–1855: 102). Similarly, in the Hahndorf area of the Adelaide Hills, the local Aboriginal people were observed making notches in their digging-sticks upon the appearance of each new Moon to mark their own age (Hahn 1838–1839 [1964: 130,131]). However, it is doubtful that this served as a long term counting device. Some activities were governed by the phases of the Moon. For instance, a colonist noted that 'at every new Moon they [Aboriginal people] also light fires in the hills. From this fact, people conclude that they adore and worship the Moon' (Hahn 1838–1839 [1964: 133]). Moonlight was regarded as a deterrent for harmful spirits, who were chiefly active during the darkness of night.[39] The Ramindjeri called a half Moon, 'Marger-ald-narte', meaning 'Moon of piece', whereas a full Moon was 'Marger-ald rakkuni', that is 'Moon of round' (Meyer 1843: 78). In the southern Coorong area, 'Mercuri' (= Markeri) reportedly meant both the Moon and the night (Wells 1852–1855: 112). In the Lower South East, the Booandik term for the Moon, Toongoom, was reportedly also used to indicate a period of a month (Smith 1880: 131).

Sun

In the Adelaide area, the Sun, known as Tindu, was said to be female and, with her several sisters, had a negative influence over humans.[40] One of the afflictions perceived as caused by the Sun was a very painful and often fatal cough. The Moon taught the Adelaide people that should a very ill person offer a hand of coughed up phlegm to the Sun as a form of appeasement, that person might recover (Wyatt 1879: 166,167). However, if not properly appeased, the Sun said 'Noornte oornte, wirrilla pallone ningko' which means 'Go away, quickly dead you'. The Sun also had a negative effect on the Moon who was old and suffered from a strong cough. She was able to easily beat him every month so that he died. But in dying he revived again. Of the Sun and the Moon it was said 'Tikkan teendo, wandeen olte, karkara tatteen, boora pallon'.[41] This reportedly meant that the Sun rested or slept at night while the Moon climbed and eventually died. By another account the Sun sat in her house at night and ate fish.[42] It is likely that the observable difference in the relative strength of illumination between the Sun and the Moon is a factor in this perceived Aboriginal dichotomy of strength versus weakness. The term, 'Tindu', or variations of it, appears in several languages to the north and west of the Adelaide area.[43] In Ngadjuri mythology of the Mid North of South Australia, the Sun went to the Underworld (= Land of the West) for the first time as the result of the killing of an old woman and her two dogs (Tindale 1937). Tindale's explanation for this myth is that it is an Aboriginal record of a complete lunar eclipse that occurred in 1793.

The Ramindjeri people of Encounter Bay believed that the Sun was female. Meyer recorded:

> The Sun they consider to be female, who, when she sets, passes the dwelling-places of the dead. As she approaches, the men assemble, and divide into two bodies, leaving a road for her to pass between them; they invite her to stay with them, which she can only do for a short time, as she must be ready for her journey for the next day. For favours granted to some one among them she receives a present of a red kangaroo skin; and, therefore, in the morning, when she rises, appears in a red dress (Meyer 1846 [1879: 200]).

Their name for Sun was 'Thulderni'.[44] For the Yaraldi of the Lower Lakes, there was a similar tradition recorded (Berndt & Berndt 1993: 232,233,444). The Sun's heat, 'watalti', was the nga:tji (spirit familiar) of the Wutaltinyeri descent group north of Meningie on the shore of Lake Albert in the Lower Murray, whereas the Sun's disc, 'nangge', was that of another unnamed group (Berndt & Berndt 1993: 215). In the Lower Murray area, Aboriginal people generally called the Sun, 'Nangge' (Meyer 1843: 84; Taplin 1874 [1879: 131]; Taplin 1879: 139,142).[45] In the Mid Murray area, the term for sun was 'Nanka', or variations of it.[46] Here, a local landowning group was known as the 'Sun people' (Tindale 1953: 7).[47]

There was a belief amongst the Tangani of the Coorong that the Sun was in earlier times much brighter. Tindale records:

> Wange [sic.? = Nangge?] was a Sun woman, a being who, in ancient times, climbed into the heavens where she carried firesticks; but these firesticks did little for people on earth in keeping them from being cold. The light from her firesticks was too bright. Another being still on earth, named Nure:le, magically forced her to be less vigorous in waving her firesticks, instead of affording much bright light there was a greater amount of red glow. Thus people could remain warm (Tindale 1983: 7).

This belief relates to the observation by Aboriginal people that for maximum heat their own campfires needed more red coals, and less bright flame. In their society it was the older women who had responsibility for maintaining the fires. During the initiations in the South East of South Australia, the female gender of the Sun Being was reportedly an embarrassment to the Aboriginal people (Tindale 1983: 9). Her role in the ceremony was represented temporarily by 'her brother', who carried paired firesticks which were symbolic of those that lit up the earth from above. However, it is unclear whether this was a pre-European practice, or one resulting from more contact between Aboriginal groups after European colonisation.

The Tangani people of the Coorong called the day, 'nangi', and the Sun itself was 'Tulduruwi' or 'Taldarawei'.[48] In the southern Coorong region, the recorded name for Sun was 'Thildiroor', with a related term, 'thildirooi', which was said to mean a 'day' (Wells 1852–1855: 112). A nearby inland group, the Potaruwutj people, apparently called a day, 'kado', and the Sun, 'Kardu', and Sunrise, 'Tarkinj'.[49] In the Lower South East, the Booandik term for both the Sun and a day was reportedly 'Karo', the rising Sun, 'Yoong-in-karo', and the Sun having set was 'Kap-an-a-karo' (Smith 1880: 129,132,134).[50] In the South East of South Australia, and the adjacent area of south-western Victoria, the Sun appears generally to have been considered a female entity (Dawson 1881: 99).

Milky Way

The Aboriginal cosmic landscape was dominated by the Milky Way. It was considered by the Adelaide people to be a large river, along the banks of which reeds were growing (Teichelmann & Schurmann 1840, vol.2: 11,35,38,57,62; Teichelmann 1841: 8). The Milky Way was given the name 'Wodliparri', which literally means 'hut-river'. The Ngadjuri people of the Mid North of South Australia had a similar term for the Milky Way, 'Walibari' (Berndt & Vogelsang 1941: 7), as did the Nukunu people in the southern Flinders Ranges, who called it 'Waarli Pari' (Hercus 1992: 29). Similarly, the Gundidjmara in south-western Victoria reportedly considered this large cosmic feature to be a 'big river' (Dawson 1881: 99). The habitations of the deceased as a group were an important element of the Milky Way. A nineteenth century observer claimed that:

> In parts of Queensland and South Australia the natives believed the "Milky Way" to be a sort of celestial place for disembodied spirits. They said it was the smoke proceeding from celestial grass which had been set on fire by their departed women, the signal being intended to guide the ghosts of the deceased to the eternal camp fires of the tribe.[51]

Similarly, to the Ngaiawang of the Mid Murray, the Milky Way was symbolic of the Murray River, with the stars being men hunting game in the mallee on either side.[52] For the Nukunu, another important association with the Milky Way was that it represented a huge tree, like a ceremonial pole (Hercus 1992: 13–16). In this context, it was part of the Urumbula song-line which runs from the vicinity of Port Augusta all the way to the Gulf of Carpentaria.[53] The Milky Way was therefore widely considered an important topographical feature of the cosmic landscape.

The Adelaide people considered that the dark spots in the Milky Way were water lagoons in which a 'magnificent animal' or 'monster' called Yura lived. One record actually describes Yura as

a group of monsters, although other accounts mention Yura as a single being (Schurmann Diaries 5 June 1839; Teichelmann 1841: 8). These dark spots were known as Yurakauwe, which translates as 'monster-water'. Adelaide people claimed that the monster Yura was vicious and would swallow people who did not hide from him. When he appeared, an abundance of water was created. Yura was the 'author' of circumcision and first taught the practice to the ancestors of the Adelaide people. He punished those who neglected it. Yura lived in the sky with Paitya, another dangerous monster. Schurmann recorded that women and children were not allowed to know of these things.

Yura is analogous to the Akurra, the huge mythical water snake of the Flinders Ranges (Tunbridge 1988: 5–11), and to Akaru, the Ngadjuri equivalent (Berndt & Vogelsang 1941: 9). The Akurra was sometimes considered to be a single being, although able to be in many places at once. This characteristic may help to explain how in the Adelaide area beings like the Yura and the Monana can be conceived as existing both in the singular and plural forms. Similarities of Yura with the Australian-wide Rainbow Serpent mythology are also significant (see Radcliffe Brown 1930).

According to Meyer (1846 [1879: 202]), the Milky Way was considered by the Ramindjeri people of the extended Lower Murray area to be a row of huts, among which were heaps of ashes and ascending smoke. Another account of the Milky Way, given by George Taplin, concerns the Ngurunderi myth (1874 [1879: 57]). Taplin related that when Ngurunderi caused the drowning of his fleeing wives, a flood occurred at Point McLeay (Rauwoke). Nepeli, who was living there, was forced to pull up his canoe to the top of the cliff (now called 'Big Hill'). From here, the canoe was transported to Waiirri, and thereafter the dense part of the Milky Way was said to be the canoe of Nepeli floating in the Heavens. According to Berndt's informant, Karloan, Ngurunderi made the Milky Way while at Mount Misery by placing his canoe in the sky (Berndt 1940: 173; Berndt & Berndt 1993: 224). He explained that the Milky Way was called 'Ngurunderi yuki', said to mean 'Ngurunderi's canoe'. Both Nepeli and Waiyungari were considered to live in the Milky Way (Smith 1930: 183). A version recorded by Harvey (1939) from Aboriginal informants, Jacob Harris and Creighton Unaipon, suggests that Nepeli threw his spear into the sky and this became the Milky Way.

Magellanic Clouds

The Adelaide people called the Magellanic clouds, 'Ngakallamurro', said to literally mean 'paroquet-ashes' (Teichelmann & Schurmann 1840, vol.2: 25,30; Teichelmann 1841: 8). Being white, they represent the ashes of a species of 'paroquet' known as the Blue Mountain lorikeet (*Trichoglossus haematodus*). These birds were assembled there by one of the constellations and were later treacherously roasted.

The Magellanic Clouds were known in the Lower Murray as Prolggi, which was translated as 'cranes' (Taplin 1879: 133). In Australian English we know them as brolgas or native companions.[54] The Yaraldi considered that there were two Prolggi in the sky, having got there after fighting with the emu spirit, Pindjali, who also became a heavenly body (Tindale 1931–34: 207–209; 1938–56: 33–61; Berndt & Berndt 1993:15,164,456–458).[55] Tindale recorded the following account from Mark Wilson, a Yaraldi man:

> The brolgas, knowing that the emus would hunt them and kill them, flew up into the air, circling around, higher and higher, until they reached the sky. They found it to be a good country to live in, so they stopped there. You can see them in the heavens at night, "in the form of two patches of clouds, like wisps of smoke, at the end of the Milky Way." The aborigines' belief is that when any one of them is knocked down and left bruised and unconscious on the ground by a person from another tribe, the brolgas come down, lift him up and guide him home (Tindale 1931–34: 207–9).

To the Lower Murray people then, the brolgas in the Skyworld exerted a benign influence. A similar account was provided to Tindale (1934–37: 60) from a Meintangk informant who claimed that the emu concerned was to be seen in the sky just under the Southern Cross. The fight in the myth was apparently due to the jealousy of the emu over the brolga's children. This mythology appears to be related to Gundidjmara beliefs, which held that the larger cloud was the 'male native companion' or 'gigantic crane', the smaller cloud being the female equivalent (Dawson 1881: 99). A similar version has also been recorded in the Kamilaroi language of northern central New South Wales (Austin & Tindale 1985). As with their terrestrial counterparts, these celestial spirit beings migrated according to the season. In the winter sky, the brolgas are seen lying to the south-east and then south of the Milky Way (Tindale 1938–56: 57). In summer they shift towards the western side.

Pleiades

The Adelaide people considered the higher landscape to be similarly organised to the lower, to the extent that the celestial bodies were believed to obey the same laws as men and animals upon earth. For example, the Pleiades, which were called 'Mankamankarranna' (also Mankankarrana and Mangkamangkarranna), were considered to be girls who gathered roots and other vegetables around them in the sky.[56] The Narangga people of Yorke Peninsula had a similar mythology. They called the Pleiades the 'Mangga Manggaridi', who were said to be 'maids' (Black 1920: 87). In the Parnkalla language of eastern Eyre Peninsula, the Pleiades were recorded as women, called 'Pallarri' (Schurmann 1844, vol.2: 51). Similarly, in Nukunu mythology, the seven sisters or 'Purlara', were reportedly chased into the sky by three brothers (Hercus 1992: 7,16,27). One sister became sick and stayed on the terrestrial landscape. These are clearly related accounts to the Seven Sisters Dreaming of the Western Desert, where the young women, called Kungkarungkara, are chased by Orion (Tindale 1959). Here they appear in the dawn sky during April/May, being the start of a ceremonial cycle.[57] The southern myths also bear resemblance to the Mankarawora (Pleiades) of the Diyari in the north-east of South Australia (Berndt & Vogelsang 1941: 8). In the cosmology of the Adnyamathanha people of the Flinders Ranges, the Pleiades were known as the Makara or Artunyi, meaning a group of women (Mountford 1939: 103,104; 1976: 33–35; Mountford & Roberts 1970: 56; Tunbridge 1988: 16). They believed that the Akurra serpent ancestor ate the Artunyi women at Yandara in New South Wales, and that these women were later released into the sky when he drowned. Most beliefs concerning the Pleiades simply record a number of sisters, because Aboriginal counting systems before European contact had little use for figures greater than three.

In the account of cosmology recorded from Billy Poole of the Lake Albert area, the Pleiades represented the eggs that another constellation, a Turkey, was sitting upon.[58] For the southern Coorong district, 'the Seven Stars are black men sitting round a fire, of course they are smoking (Wells 1852–1855: 99)'. In south-western Victoria there are various accounts of the Pleiades, representing a flock of female cockatoos, or six women whose 'Queen' had been taken by the crow, signified by Canopus (Dawson 1881: 100). The Pleiades are probably the Yatuka constellation that Yaraldi people believed comprised six girls and one boy (Berndt & Berndt 1993: 163,164). This may relate to the Tangani belief that the Pleiades, called by them Mantjingga, were seven or eight girls and a single boy.[59] He went with them because his fire had gone out. Munaijeri was one of the Mantjingga who went away (Tindale 1930–52: 290). The Pleiades are known in many cultures of the world as the Seven Sisters.[60]

Orion

In the Adelaide region, the stars of the Orion constellation were called Tinniinyarra (also Tinniinyaranna and Kurkukurkurra). They were considered to be youths who hunted kangaroos, emus and other game on the great celestial plain, called the Womma.[61] The mother of the Tinniinyarra was a red star called Madletaltarni (Teichelmann & Schurmann 1840, vol.2: 17,37,42). This is probably the star astronomers call Betelguese. The father of the Tinniinyarra was a star called Parnakkoyerli. To the Parnkalla people of eastern Eyre Peninsula, the Orion constellation could be termed either Minye or Mirrarri, considered to be men or boys (Schurmann 1884, vol.2: 33). In the Western Desert mythology, Orion, called Njiru, chased the Pleiades across the terrestrial landscape, as he still does in the Skyworld (Tindale 1959).

A version of the Waiyungari story recorded in the Lower Murray region from an early Narrung resident has Waiyungari and the two escaping wives of Nepeli, who are sisters, becoming the three great stars of Orion's belt.[62] As reported below, Tindale's version has Waiyungari becoming the planet Mars. In relation to Orion's belt, there is a close parallel in the beliefs of the Gundidjmara people of south-western Victoria where three stars were the sisters of Sirius who always followed him (Dawson 1881: 100). There also, a red star in the constellation of Orion was called 'fire', and was masculine. The Ngalwara constellation recorded in Yaraldi cosmology, which was perceived as six young men (Berndt & Berndt 1993: 164), is possibly Orion. The Tangani called the seven boys the Ngawiri.[63]

The Southern Cross And The Coal Sack

In the Ngadjuri language of the Mid North of South Australia, the Southern Cross was called

'Wildu', the eagle (Berndt & Vogelsang 1941: 9). To the Parnkalla people of eastern Eyre Peninsula, the Southern Cross and adjacent stars were termed 'Kadnakadna purdli' (Schurmann 1844, vol.2: 9). The Tangani people of the Coorong had a death fear song concerning the arrival of a smallpox epidemic (Tindale 1937: 111,112; Tindale 1941: 233,234).[64] As part of the story of this song, a 'dream man', Kulda, came down to the lower landscape from the Southern Cross, called Yu:ki.[65] He foretold the coming of death, with his 'pointing bone' taking the spirits of the dead with him to Kangaroo Island. Tindale recorded that:

> The natives saw a man (meteor) come out of Yuuki, the Southern Cross; they heard a noise and looked up (meinyanga nampi). They saw him move his hands and said 'Ha! peika bakki' ('Ah! death coming'; 'peik' = 'die'). The natives could not stand the murki [smallpox] and a great many died. The meteor was a maldawuli man whose name was Kuldalai, he travelled westward through the sky and beckoned to indicate that all the people should follow him. Then the smallpox came and many people followed him (literally went west) across to Kangaroo Island and beyond (Tindale 1931–34: 232).

Furthermore, Tindale (1931–34: 251,252) recorded that Kulda appeared 'like a bright flash, too bright to look.' The method he used to attract people was first by smoke signals, then by waving hands. Tindale's Aboriginal informants believed that many of the bones in the sandhills of the Lower Murray belonged to people whom Kulda had beckoned to follow him. This account is further illustration of the perceived connections between the Skyworld, Land to the West, and the terrestrial landscape.

A Meintangk informant told Tindale (1934–37: 60) that 'The black patch (Coal Sack) in the Southern Cross is the emu ... The Southern Cross stars are men.' The emu in this instance was probably the spirit who fought with the brolgas, as already noted above. According to the Europeanised mythology of Smith, the 'Grandmother Spirit', known as Puckowe, was considered by Lower Murray people to inhabit the dark spot in the Milky Way, known as the Coal Sack (Smith 1930: 184,185,199). Aboriginal healers in the Lower Murray could reportedly appeal to her for help. The Gundidjmara people in south-western Victoria apparently believed that a 'bunyip', a mythical water spirit, lived simultaneously both in the Coal Sack and in parts of the terrestrial landscape (Dawson 1881: 99).

Lyra

The 'doctor men' of the Tangani interpreted the appearance of Vega, called by them Lawarikark, in the constellation of Lyra as indicating the nesting time of mallee fowls (Tindale 1983: 26).[66] These birds, called lawari or lowan, make a harsh scolding noise when racking the leaves for their nests. For this reason, Aboriginal people considered this constellation to have quarrelsome properties.

Seasonal Bodies

To the Adelaide people, the arrival of Parna in early autumn indicated the change of season and was a sign that large and waterproof huts needed to be built in the Adelaide foothills (Gell 1842 [reprint 1988: 7,9]). The Aboriginal place name for a hilltop campsite at Morphett Vale, south of Adelaide, was Parnangga.[67] This reportedly meant 'autumn rains', and referred to the appearance of Parna.[68] Similarly the Ngarrindjeri called autumn, Marangani, which is a time when stars of this name appear (Taplin 1879: 126). The Yaraldi term recorded for autumn, Marangalkadi, was said to mean 'pertaining to the crow' (Berndt & Berndt 1993: 21,76,240). Marangani was a crow (more properly called a raven) in the creative period of the Yaraldi 'Dreamtime' (Meyer 1843: 78; Berndt & Berndt 1993: 163,240–242). According to Yaraldi tradition, the autumn stars are low in the south-eastern sky because it was to the south-east of the Lower Murray that the crow spirit entered the Skyworld. When Marangani was at its zenith, both animals and humans were thought to enter the 'rutting season' (Tindale 1930–52: 266). Women in particular were considered to be easily affected by Marangani, making some individuals promiscuous.

In the Adelaide area, spring was termed Willutti or Wiltutti (Teichelmann & Schurmann 1840, vol.2: 55; Teichelmann 1857). It was under the influence of the constellation of the eagle, Wilto. It is likely that Wilto was the Southern Cross, through the apparent relationship between Wiltu in the Adelaide language and Wildu of the Ngadjuri mentioned above. Similarly, in the Adelaide area summer was governed by the wild turkey constellation, Wolta (Teichelmann & Schurmann 1840, vol.2: 57,58; Teichelmann 1857). Summer was therefore called Woltatti. The linking of seasons with the movements of celestial bodies is common across Australia (Clarke 1990: 6; Clarke 1991a: 59).

Unidentified Stars

In the ethnographies of southern South Australia, there are several names for stars where identification is difficult due to lack of description. One example is Njengari, who reportedly was once a mortal on earth (Tindale 1941: 235; Tindale 1987: 12). He had a happy nature and was often observed dancing. He created a smooth dancing spot along the coast at a place called Watbardok in the Normanville area south of Adelaide. This later became an excellent fishing spot as nets could be drawn here without snagging. Njengari was a clansman of Tjirbruki, who was also a landscape-creating ancestor. Njengari was eventually transformed into a star. There are also recorded names from the Adelaide language for constellations such as 'Mattinyi' and 'Kumomari', for which there is no European equivalent given (Teichelmann & Schurmann 1840, vol.2: 13,22). Similarly, 'Yurdlakka' was said to be 'a star or constellation' in the Parnkalla language (Schurmann 1844, vol.2: 87). The identity of these was not known to the recorder. In the Gundidjmara region of south-western Victoria, larger stars (and probably planets) were feminine and considered to be 'sisters of the Sun' (Dawson 1881: 99).

In the Lower Murray region, there was a celestial body that appeared every few years as a good omen. Tindale reports:

> Nalkari – a special star or planet which appears every four or five years. It causes the fish to die in thousands and to float along the river banks. The people are glad when they see Nalkari for it means that much food can be obtained (Tindale 1934–37: 147).

The identity of this cosmic body is unknown, although it seems unlikely to be a comet, as these were universally held in great fear.

Planets

In the Adelaide region, the Sun-father, Teendo Yerle, had several wives which Schurmann thought were probably planets.[69] In contrast to the sisters of Teendo Yerle who were bad, the wives were considered to be very good. In the case of the Lower Murray traditions, a version of the Waiyungari myth provided a Yaraldi account of the origin of the planet Mars (Tindale 1935). Tindale had several Aboriginal sources who confirmed that Waiyungari became Mars after he and the two wives of Nepeli fled into the sky. The Ramindjeri people considered that Waiyungari became a 'star' (Meyer 1843: 105). Waiyungari was said to actually mean 'he who returns to the stars' (Smith 1930: 250). However, there is no ethnographic record of the celestial identity of the two women of who accompanied him. A past Government Astronomer, G. F. Dodwell, suggested that they might have been perceived as Jupiter and Venus, as both of these planets move over the Heavens, coming into conjunction with Mars (cited in Tindale 1931–34: 189; Tindale 1935: 270–274). However, another record of the Waiyungari myth stated that his home was in the Milky Way (Smith 1930: 183,251). According to this version, Aboriginal people pointed out three stars in the eastern sky which represented Waiyungari and his two wives. Other accounts of Mars, perhaps associated with the Waiyungari mythology, state that when the 'red star' is shining at its 'hottest' and 'brightest', it is blamed for increasing sexual desire (Berndt & Berndt 1951: 223; Berndt & Berndt 1993: 164). To the Gundidjmara people of south-western Victoria, Mars was a feminine entity (Dawson 1881: 99).

According to George Taplin (1879: 135,140), Venus was termed Warte by the Ngarrindjeri. This term has also been recorded to mean 'firestick' (Meyer 1843: 106). Presumably the relative strong brightness of Venus adds to its association with fire. The Gundidjmara apparently considered Venus to be the 'mother of the sun' (Dawson 1881: 99). This tradition is possibly linked to the notion that Venus sometimes accompanied the Sun across the Skyworld, as it is visible during the day. In the recorded Parnkalla language of eastern Eyre Peninsula, the 'evening star' (Venus) was 'Kabminye' (Schurmann 1844, vol.2: 9). At the confluence of the Murray and Darling Rivers, the 'evening star' (Venus) was reportedly called 'Pudli' or 'Pudali' (Tindale 1930–52: 255), although this may have simply meant 'a star'.

Meteors

Although many of the celestial bodies were linked to each other through kinship, in the Adelaide region meteoric lights (or shooting stars) were said to be 'orphans'.[70] Their ephemeral and unregulated nature may have contributed to this classification. Generally, meteors were considered to be bad omens, especially in times of great social disruption. The account of Kulda, perceived as a meteor who came out of the Southern Cross, is a good illustration of this. Furthermore, when a

falling star was seen, the Tangani people of the Coorong reportedly said 'peika bak:i', that is 'death coming'.[71] Tindale (1938) linked the myth of Prupi, a cannibalistic woman living along the southern Coorong who was killed by fire, with a meteorite fall in the area. Furthermore, to the Gundidjmara people of south-western Victoria, a meteor represented 'deformity' (Dawson 1881: 101). In north-western Victoria, a meteor 'portends evil to those that have lost a front tooth, to avert which they stir the fire and cast about firebrands (Stanbridge 1857: 140)'.

Comets

The Adelaide people believed that Teendo Yerle or Sun-father, had a pair of evil sisters who were 'long' and probably comets.[72] Aboriginal people here considered most of the unusual cosmic phenomenon they observed to be a 'sure harbinger of death [which filled] them with awe and terror' (Schurmann 1846 [1879: 242]). In March 1843, a comet visible to Aboriginal people from along the Murray River was taken as a:

> harbinger of all kinds of calamities, and more especially to the white people. It was considered that the comet would overthrow Adelaide, destroying all Europeans and their houses, and then to take a course up the Murray and past the Rufus River causing havoc in its path' (Eyre 1845, vol.2: 358,359).[73]

It was believed to have been created by northern Aboriginal people who were powerful sorcerers. On this occasion, the Resident Magistrate at Moorunde, Eyre, was told by river Aboriginal people to go to Adelaide and procure the release of an Aboriginal man from the north gaoled for assaulting a shepherd. If this was done, he was told that disaster would be averted. The disquiet caused by unusual cosmic phenomena appears to have been widespread. In the Port Lincoln area, the 1843 comet caused Aboriginal people to hide in caves (Schurmann 1846 [1987: 242]).[74] The Gundidjmara people of south-western Victoria considered a comet to be a great spirit (Dawson 1881: 101).

Other Celestial Events

There were also other celestial events that were perceived to be bad signs. In the Adelaide area, the Southern Lights foretold disease.[75] Furthermore, an eclipse was considered to cause death and destruction. Aboriginal people at Point McLeay in the Lower Murray area were very fearful of the Aurora Australis and the eclipse of the Moon (Taplin Journals 4–7 June 1859, 2 September 1859). Both events were said to have been created by 'wild blackfellows', an early Aboriginal English term for 'uncivilised' groups living beyond the European colonial frontier. Such people were often feared as sorcerers. In the case of the Aurora Australis, it foretold the arrival of these dangerous human/spirit beings.

Discussion

This paper illustrates that the connections between Skyworld, terrestrial land and the Underworld were crucial parts of Aboriginal cosmology. Perceived events and influences from the cosmic landscape had a significant role in the ordering of human life. The observable seasonal changes in the cosmos, due to the movement of planets and constellations, mimicked the terrestrial movements of people and animals. These observances would have strengthened the perception that the cosmos was a landscape. These psychic regions were considered by Aboriginal people to be part of the land that they 'used'. With a social kinship system linking many of the celestial bodies, it can be seen that the cosmos and earthly landscapes were in at least one sense reflections of each other. The total cultural landscape was humanised by the people living within it.

Acknowledgments

This paper is based on material in the author's Ph.D thesis, which was supervised by Chris Anderson, Peter Smailes and Kingsley Garbett. Drafts of this paper were commented upon by Jane Simpson, Rob Amery, Adele Pring, Richard Kimber and Philip Jones.

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Endnotes

1 Quarterly Report (1 October to 31 December 1837) from Wyatt to the Colonial Secretary, dated 1 January 1838 (Colonial Secretary Reports, 1838/3 & 1838/69, Public Records Office, Adelaide).

2 For evidence of Taplin's incorporation of his wife's thoughts and observances see Taplin Journals, 12 September 1860.

3 Tindale's journals, field notebooks, and the 'Milerum' manuscript are also important ethnographic sources. This material is housed in the Anthropology Archives, South Australian Museum.

4 Tindale records that Robert Mason remembered David Unaipon turning up at Swan Reach many years ago, offering 5 shillings for each Aboriginal story he was told (Tindale 1953: 39). Apparently, Ramsay Smith in turn paid him 10 shillings per story he collected. Unaipon collected mythology from Aboriginal contacts he had with communities across South Australia.

5 For southern South Australia, see Clarke (1990; 1991a: 63–66). Mountford (1958: 144–146,170–177), & Sims (1978) describe the cultural landscape for the Tiwi of Melville & Bathurst Islands in the Northern Territory.

6 In the Adelaide region, the Underworld or Land to the West was known by variations of 'Pindi' (Clarke 1991a: 64,65). In the southern Flinders Ranges it was termed 'Kintyura' (Hercus 1992: 17,20,30). It is interesting to note that southern groups believed that the Sun entered the Underworld through diving into the sea, whereas groups near Lake Eyre in Central Australia believed that it disappeared into the ground at a place called 'Dityi-minka', reportedly meaning 'Hole of the Sun' (Howitt 1904: 427,428).

7 This is consistent with the individual losing its corporeal identity after death, as noted for the Walbiri in Central Australia (Meggitt 1962: 317).

8 For instance, see the cosmologies described by Stanbridge (1857), Smyth (1878, vol.1: 430–434), & MacPherson (1882) for northern Victoria, Roth (1903: 7,8) for northern Queensland, Howitt (1904: 426–434) for south eastern Australia, & Maegraith (1932) for Central Australia.

9 This is quoted by Cawthorne (1844 [reprint 1926: 24,25]) without acknowledgment to Teichelmann.

10 Another word in the Adelaide language that referred to sky, heaven, & height is 'kaŕra' (Teichelmann & Schurmann 1840, pt 2: 10).

11 Other Parnkalla terms associated with the Skyworld include 'Wangkurtu kurtu' – 'heaven; 'Pandarri' – 'sky, heaven'; & 'Walkurri' – 'heaven' (Schurmann 1844, vol.2: 52,67,68). The 'sky' or 'ether' was 'ilkari' (Schurmann 1884, vol.2: 6).

12 Foster (1990) discusses the role of the Native Location & Native School.

13 Other variations include Waieruwar (= Wyirrewarre), Wyirri (= Waiyirri) & Wairalt, depending on linguistic context, respectively meaning 'Heaven', 'to Heaven', 'in Heaven'. These variations are illustrated by Taplin (1874 [1879:

131]; 1879: 38,132,142). See also Tanganekald vocabulary cards, Tindale collection, Anthropology Archives, South Australian Museum.

14 Penney (as 'Cuique'), *South Australian Magazine*, September 1842, 1(xii): 467–472.

15 Tindale, no date, 'Milerum', Stage A, #6. Anthropology Archives, South Australian Museum.

16 Schurmann's account is similar to Wyatt's but differs in that Monana represents a group of beings, not one individual spirit (Schurmann Diaries 5 June 1839; Wyatt 1879:166,181).

17 There are aspects of the Pulyallana mythology that appear to be closely related to the mythology of Ngurunderi in the Lower Murray (Clarke 1995). Both ancestors were chasing their wives across the landscape while creating many of the landforms, eventually drowning the women.

18 The 'Dreamtime' represents an Aboriginal English gloss of a range of meanings. The 'Dreaming' can loosely be defined as the whole body of mythology in Aboriginal Australia that provides some insight into significant cultural events.

19 Schurmann in a newspaper article titled 'The Aborigines of South Australia' in *The South Australian Colonist*, 10 March 1840.

20 *Adelaide Register*, 5 October 1887.

21 According to Tindale (no date, 'Milerum', Stage A, #1, Anthropology Archives, South Australian Museum) the Tangani considered that there were seven stars shaped like a stingray.

22 For a destination of the spirit of these warriors see Taplin (1874 [1879: 18], & Meyer (1846 [1879: 201]). A variation in the spelling of Nepeli in the literature is Nepele. Variations of Waiyungari include Wyungare, Wyangaure & Waijungari. Meyer (1843, vol.2: 105) lists 'Waiyungari' simply as the 'name of a star'. Elsewhere, such as south western Victoria, major spirit ancestors were also perceived as living in the Skyworld (Dawson 1881: 49).

23 Schurmann Diaries (5–6 June 1839), & Wyatt (1879: 166,181). Also see Schurmann in a newspaper article titled 'The Aborigines of South Australia' in *The South Australian Colonist*, 10 March 1840. Monaincherloo also refers to 'a very remote time; ancient' (Teichelmann & Schurmann 1840, vol.2: 25).

24 Schurmann Diaries (5 June 1839). Also see Schurmann in a newspaper article titled 'The Aborigines of South Australia' in *The South Australian Colonist*, 10 March 1840.

25 Schurmann Diaries (5 June 1839). Also see Schurmann in a newspaper article titled 'The Aborigines of South Australia' in *The South Australian Colonist*, 10 March 1840.

26 Clarke (1990; 1991a: 65,66) outlines early Adelaide Aboriginal beliefs in the afterlife.

27 For Christian influences upon Aboriginal culture in southern South Australia, see Berndt & Berndt (1993: 215), & Clarke (1995: 150–152).

28 There is much variation in the spelling of this ancestral spirit in the literature (see Clarke 1991: 66–68). This paper follows the standard spelling set by Tindale (1987).

29 Teichelmann & Schurmann (1840, vol.2: 41). Also see L. Piesse in a newspaper article titled 'The language of the natives of South Australia' in *The South Australian Colonist*, 14 July 1840. A variation in the recording of 'purli' is 'poulee'.

30 Other recorded variations in the Ngaiawang language are 'pidli' (Moorhouse 1843 [1935: 34]), & 'pille' (Tindale 1964: 7).

31 Schurmann Diaries (22 July 1839), Teichelmann & Schurmann (1840, vol.2: 7,38,46), Teichelmann (1841: 9), Wyatt (1879: 166,167), & Stephens (1889: 500). Also see 'The Transactions of the Statistical Society – Report on the Aborigines of South Australia', *The Southern Australian*, 11 January 1842. Variations recorded for Kakirra include Karkara & Cackera. Teichelmann (1857) also uses the term, Marrero. Tindale (1974: 48,49) notes that in many parts of Australia, 'Kakara', as the word for Moon or Sun is also used to mean 'the east'. He speculates that this relationship is based on the perception of the east being where these celestial bodies enter the sky.

32 The Erawirung people in the Mid Murray region used the term, 'Kakere', for the Moon (Tindale 1930–52: 251).). In a coagnatic language, Ngaiawang, the Moon was called 'Kokarar' (Tindale 1964: 5), 'Kakur' or 'Kagurre' (Moorhouse 1843 [1935: 18]). Another word for Moon that Tindale (1953: 7) records for the Mid Murray region is 'Kagura'. It was recorded in the Moorundie area as 'Kokerer' (Scott 1840–1907).

33 In the Whyalla area of Eyre Peninsula, Bira was perceived as an 'old man from the moon' who killed one of the seven sisters, while chasing the other ones across the landscape (*Advertiser*, 14 April 1990). Schurmann (1884: 3,57) records the Moon in the Parnkalla language of eastern Eyre Peninsula as 'Pirra'. Similar terms recorded elsewhere in the Central Lakes cultural bloc, such as 'Bira' in the Narangga language of Yorke Peninsula (Black 1920: 86), 'Pira' in Nukunu of the southern Flinders Ranges (Hercus 1992: 2,8,27), 'Bera' in Ngadjuri of the Mid North of South Australia, 'Vera' in Wailpi of the Flinders Ranges, & 'Pira' in Dieri of the North East of South Australia (Berndt & Vogelsang 1941: 7).

34 To the Ramindjeri, 'Markeri' was also the name of a large shell which resembled a full Moon (Meyer 1843: 78). By another account, the Encounter Bay people called the Moon, 'Mukkeri', & pronounced it very much like the English rendering of 'Mercury' (*Adelaide Observer*, 10 May 1851). Taplin also listed the Moon as 'Markeri' in his Ngarrindjeri vocabularies (1874 [1879: 131]; 1879: 134,142). The Tangane called the Moon, 'Marakari' (Tanganekald vocabulary cards, Tindale collection). In the southern Coorong district, Wells (1852–1855: 112) recorded the Moon as 'Mercuri'.

35 A similar account exists in the mythology of northern Victoria, where the main male creative ancestor, Nooralie (=Nureli, Nure:le), commands the Moon to die and the Sun to disappear (Smyth 1878: 431).

36 Tindale, no date, loose sheet in 'Milerum', 'Jobs needing further attention before typing.' Anthropology Archives, South Australian Museum.

[37] Tindale, no date, loose sheet in 'Milerum', 'Jobs needing further attention before typing.' Anthropology Archives, South Australian Museum.

[38] Smith (1880: 131) lists the Moon as 'Toongoom'.

[39] Quarterly Report (1 October to 31 December 1837) from Wyatt to the Colonial Secretary, dated 1 January 1838 (Colonial Secretary Reports, 1838/3, Public Records Office, Adelaide).

[40] Schurmann Diaries (5 June & 22 July 1839), Wyatt (1879: 166), Stephens (1889: 501), Williams (1839 [1926: 59]). Also see Schurmann in a newspaper article titled 'The Aborigines of South Australia.' in *The South Australian Colonist*, 10 March 1840. In the Adelaide area, variations in the recording of Tindu include Teendo, Tindo, & Tindoo.

[41] Wyatt (1879: 166,167). Also see letter by Wyatt dated 1 April 1838, from him to the Colonial Secretary. 69/1838. Public Records Office, Adelaide.

[42] Schurmann Diaries, 5 June & 22 July 1839.

[43] Similar names for the Sun existed across South Australia. It is 'Tjindu' in the Pitjandjara language of Central Australia (Goddard 1992: 151), & in the Wirrangu language of the West Coast (Black 1917: 7; Tindale 1928: 21). It was recorded as 'Tjindo' in Kukatha from the West Coast (Black 1920: 91). In Wongaidya from Baroota in the southern Flinders Ranges it was recorded as 'Dindo' (Black 1917: 12). The Sun was 'Yurno' in the Parnkalla language of eastern Eyre Peninsula (Schurmann 1844, vol.2: 88), 'Thirntu' in Nukunu from the southern Flinders Ranges (Hercus 1992: 28), & 'Tindo' in Narangga of Yorke Peninsula (Black 1920: 89). Similarly, in a coagnatic language, Ngadjuri, it was 'Jandu' or 'Djendu' (Berndt & Vogelsang 1941: 9). In the Flinders Ranges, it was termed 'Yuundu' (Berndt & Vogelsang 1941: 9).

[44] *Adelaide Observer*, 10 May 1851. However, 'thulderni' may be a version of the term, 'tulde', recorded by Meyer (1843: 101) to mean a star.

[45] A variation in the recording of Nangge is 'Nungge'. At Currency Creek, an early colonist records that a local European woman, with the name 'Mrs Sunman', was invariably called 'Mrs Nange' by the local Aboriginal people (*Adelaide Observer*, 10 May 1851).

[46] In the Mid Murray area, the Erawirung people used a related term, 'Nanka', for the Sun (Tindale 1930–52: 251). Similarly, the Ngaiawang people used 'Nunka' (Tindale 1964: 7). At Moorundie, it was recorded as 'Nunka' (Scott 1840–1907). Further north at the confluence of the Murray & Darling Rivers, the Maraura people called the Sun, 'Yukku', & dawn 'ngata yukui' (Tindale 1930–52: 251,253).

[47] For the Mid Murray area, Eyre (1845, vol.2: 365) suggests that an Aboriginal practice of placing stones in trees was to measure time. However, the most likely explanation was that this was to indicate the proximity of water (J. Simpson, pers.com.).

[48] Tanganekald vocabulary cards, Tindale collection. Anthropology Archives, South Australian Museum.

[49] Potaruwutj vocabulary cards, Tindale collection, Anthropology Archives, South Australian Museum.

[50] It is possible that 'kado', 'karo' & 'kardu' are the same linguistic form.

[51] Charles White in the *Adelaide Observer*, 14 January 1905.

[52] Tindale, no date, 'Milerum', Stage A, #3. Anthropology Archives, South Australian Museum.

[53] This trail may have been modified or extended as a result of the building of the Overland Telegraph Line (J. Simpson, pers.com.)

[54] The term 'prolggi', appears to be related to the Australian English term, brolga. This is a borrowing by Europeans from the Kamilaroi language in eastern New South Wales, where it was 'burralga' (Dixon *et al* 1992: 31,87,88,218). However, other Aboriginal languages from eastern Australia to the Lake Eyre region have similar terms for this bird. The Tangane people of the Coorong called this bird 'porolgi' (Tanganekald vocabulary cards, Tindale collection). The 'native companion' is an early European term for the brolga.

[55] By another account, the Granites near Kingston represented the emus of this myth (Tindale 1931–34: 192). In the South East of South Australia, this myth was sometimes used to identify Aboriginal groups (Tindale letter to Dixon, 6 March 1976, correspondence files, Anthropology Archives, South Australian Museum). The coastal people called themselves Porolgi, while inland groups were Pindjali (= Peindjali).

[56] Schurmann Diaries (12 July 1839), Teichelmann & Schurmann (1840: 19,47), & Teichelmann (1841: 9). Also see 'The Transactions of the Statistical Society – Report on the Aborigines of South Australia', *The Southern Australian*, 11 January 1842.

[57] Tindale, no date, loose sheet in 'Milerum', 'Jobs needing further attention before typing.' Anthropology Archives, South Australian Museum.

[58] *Adelaide Register*, 5 October 1887.

[59] Tindale, no date, 'Milerum', Stage A, #1. Anthropology Archives, South Australian Museum. This term may relate to the 'Manchinnga', the 'warrior who became a star' (Taplin 1874 [1879: 18]).

[60] For generalised Australian accounts, see Smith (1930: 70,345–50), & Parker (1953: 105–109). Western Desert accounts are given by Robinson (1966: 91–93), & Isaacs (1980: 152,153). The 'Seven Sisters inma' is often performed by Western Desert women visiting capital cities for public ceremonies, such as those held at the Tandanya National Aboriginal Cultural Institute in Adelaide.

[61] Schurmann Diaries (12 July 1839), Teichelmann & Schurmann (1840, vol.2: 15,17,47), Teichelmann (1841: 9). Also see 'The Transactions of the Statistical Society – Report on the Aborigines of South Australia', *The Southern Australian*, 11 January 1842.

[62] The original version appears to be C.C. Hackett in Narrung Alpha, August 1915: 10–12. A later version is Hackett (cited in Laurie 1917: 660–662). See Clarke (1995, endnote 14: 157).

[63] Tindale, no date. 'Milerum', Stage A, #1. Anthropology

Archives, South Australian Museum. Ngawiri appears to be related to 'ngauwir', meaning boy in the Ramindjeri dialect of Encounter Bay (Meyer 1843: 86).

64 Also see Tanganekald vocabulary cards, Tindale collection. As well as Tindale, no date, loose sheet in 'Milerum', 'Jobs needing further attention before typing'. Anthropology Archives, South Australian Museum.

65 It is possible that there were several constellations termed Yuki by the Lower Murray people, as this term is applied to canoes (cf. Milky Way). In the Yaraldi dialect, the Southern Cross constellation was termed Tjirilengi (McDonald 1977).

66 Tindale, no date, loose sheet in 'Milerum', 'Jobs needing further attention before typing'. Anthropology Archives, South Australian Museum. Stanbridge (1857) provides a similar myth concerning Lyra, which represents a lowan flying.

67 Tindale, Aboriginal Place Name File, Anthropology Archives, South Australian Museum.

68 Tindale, Aboriginal Place Name File, Anthropology Archives, South Australian Museum. A creek near Yankalilla in the southern Fleurieu Peninsula area is known as Parananacooka. According to Tindale, this was a rendition of the Aboriginal forms, Paranankuka and Paranankuna. Its translation was said to refer to the excreta and urine of the Autumn Star, which explained why this creek becomes very brackish at the end of summer. However, given his word derivation, this appears to be unlikely on linguistic grounds (J. Simpson, pers.com.).

69 Schurmann Diaries (5 June 1839). Also see Schurmann in a newspaper article titled 'The Aborigines of South Australia' in *The South Australian Colonist*, 10 March 1840.

70 'The Transactions of the Statistical Society – Report on the Aborigines of South Australia', *The Southern Australian*, 11 January 1842. Another reference is Moorhouse in 'Report on the Aborigines of South Australia' 14 October 1843, Document no. 1234, GRG 24/6, Public Record Office. In the Narangga langauge of Yorke Peninsula, a shooting star was 'wajaga' (Black 1920: 89).

71 Tanganekald vocabulary cards, Tindale collection, Anthropology Archives, South Australian Museum.

72 Schurmann Diaries (5 June 1839). Also see Schurmann in a newspaper article titled 'The Aborigines of South Australia' in *The South Australian Colonist*, 10 March 1840.

73 The inclusion of the Rufus River in this explanation was possibly due to it being the site of a massacre of Aboriginal people by overlanders in 1842 (see Moorhouse correspondence to Colonial Secretary, reproduced by Taplin 1879: 115–123).

74 Schurmann (1844, vol.2: 79) suggested that in the Parnkalla language of eastern Eyre Peninsula the term for comet was 'yandarri'.

75 'The Transactions of the Statistical Society – Report on the Aborigines of South Australia', *The Southern Australian*, 11 January 1842. Another reference by Moorhouse is in 'Report on the Aborigines of South Australia', 14 October 1843, Document no. 1234, GRG 24/6, Public Record Office.

THREE NEW *BEROSUS* LEACH (COLEOPTERA : HYDROPHILIDAE) FROM AUSTRALIA

C. H. S. WATTS

WATTS, C. H. S. 1996. Three new *Berosus* Leach (Coleoptera: Hydrophilidae) from Australia. *Records of the South Australian Museum* 29(2): 147–152.

Three new species of *Berosus* Leach are described from Australia: *B. sonjae*, *B. sarahae* and *B. wadeae*. Specimens of *B. wadeae* came from the Lake Eyre Basin region of South Australia and those of *B. sarahae* and *B. sonjae* from the Cairns and Townsville regions of north-east Queensland.

C. H. S. Watts, South Australian Museum, North Terrace Adelaide South Australia 5000.
Manuscript received 29 January 1996.

This paper describes two distinctive new *Berosus* which I came across whilst sorting specimens in the South Australian Museum collection (SAMA) and one collected recently in Queensland by my son. The tropical members of this genus in Australia are still poorly known and difficult to separate using the key given in Watts (1987). The three new species described here are however readily separated from any known species, warranting their description without an extensive revision of the genus.

Systematics

Berosus wadeae sp. nov.
(Figs 3, 4)

Description (number examined, 26)

Length 5.0 – 6.5 mm. Elongate-oval, not humpbacked, apex of elytron slightly elongate with one short but well marked spine a little distance from suture line (in position of outer spine in species with a pair of apical spines on elytron). Elytron yellow–brown, portions of striae darker, in a few places tending to spread to adjoining striae forming a darker patch on elytron; base of head narrowly black; appendages reddish-brown; ventral surface dark brown to black with apical ventral segment lighter in some specimens. Punctures on head, well marked, weaker and sparser in front, strong and longitudinally elongate behind. Pronotum densely covered with large strong punctures, those on disc longitudinally elongated to about twice as long as wide. Elytron with deeply impressed striae, obliterating the serial punctures except towards back; dorsal surface covered with short stout setae (often abraided off) arising from shallow, very rugose, confluent punctures giving the interstrial regions of the elytron an evenly rugose appearance which all but obscures the punctation. Ventral surface densely but finely punctured, each puncture with a short setae. Mesosternum with a weak midline keel projecting backward as a spine between mesocoxae. Midline of first ventral abdominal segment weakly keeled in extreme front. Metacoxal process raised, sharply triangular (diamond shaped area in midline shiny and devoid of sculpture). Rugose portions of meso and metafemora half to two thirds the length of respective femora, that on profemur one third length of profemur.

Male

Protarsi four-segmented, basal segment weakly expanded, about twice as long as wide and as long as second and third segment combined, second segment weakly expanded, as long as simple third segment. Male aedeagus as in figs 3 and 4.

Remarks

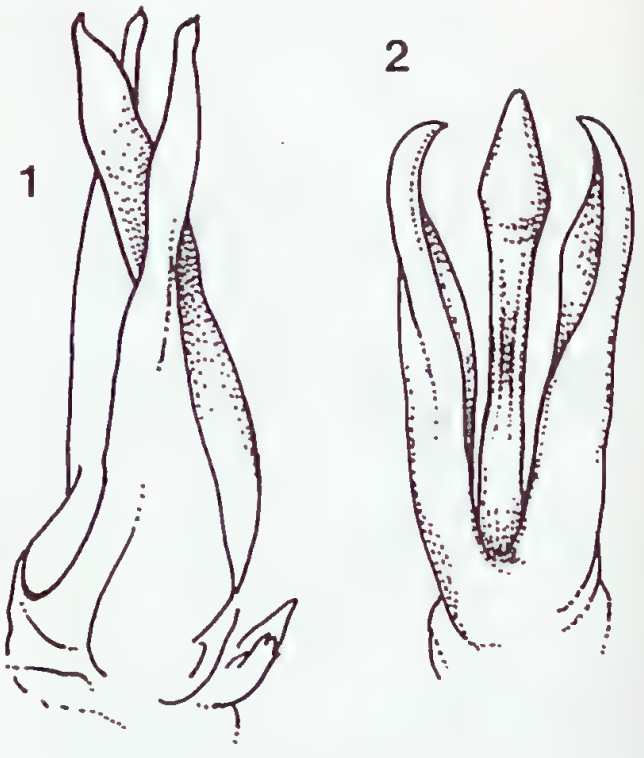
At first glance *B. wadeae* can be easily confused with the widespread and common *B. nutans* W. MacLeay which occurs in the same region. It differs from this species in several characteristics: the elytral striae are weakly impressed in *B. nutans*, strongly impressed in *B. wadeae;* the tips of the elytra are rounded in *B. nutans*, spinose in *B. wadeae;* the pronotal punctures in *B. wadeae* are strong and tend to be elongated longitudinally, in *B. nutans*, they are

small, transversely elongated and interconnected by a network of transverse grooves.

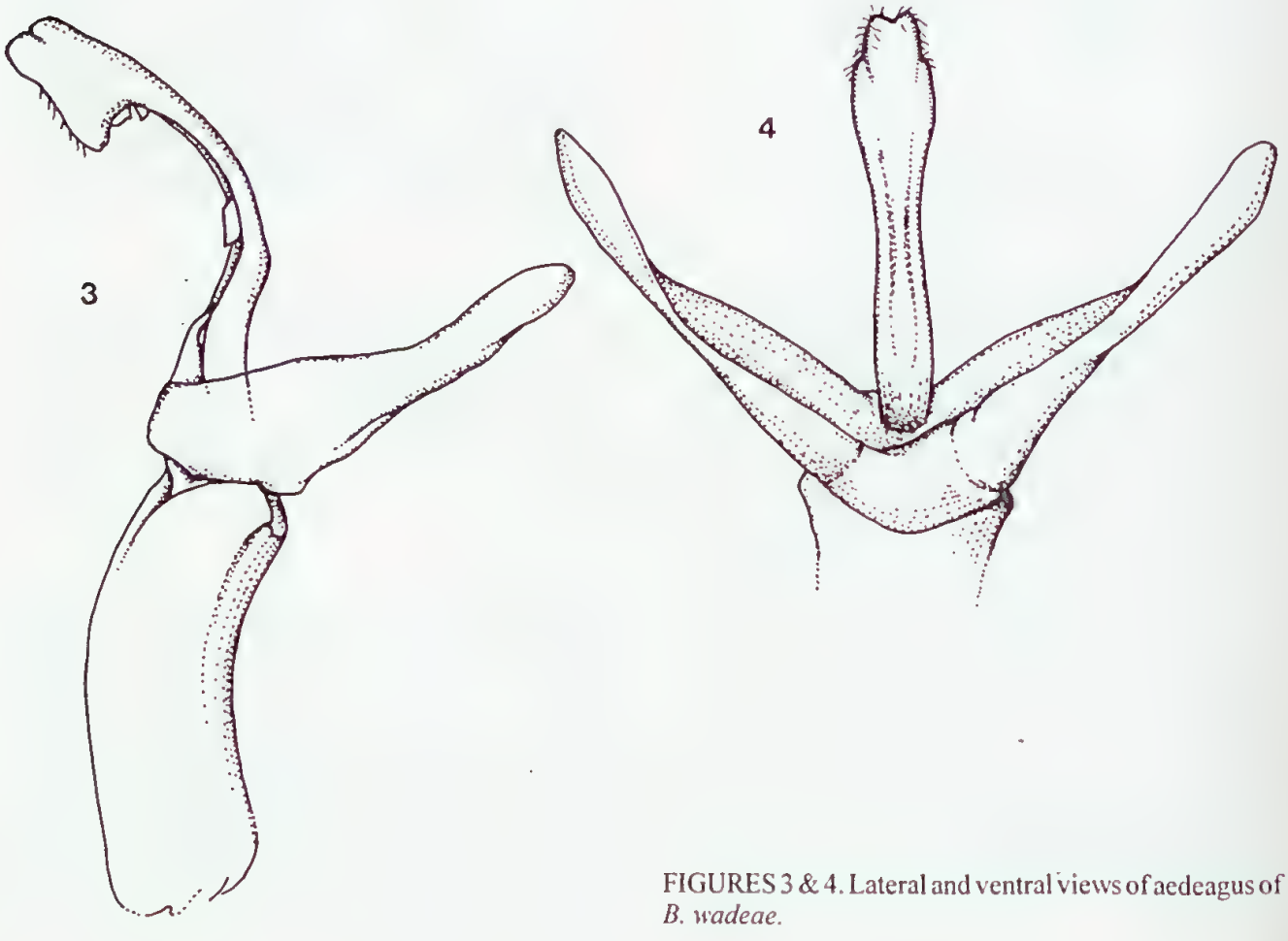
B. wadeae is similar to *B. dallasi* Watts but is larger and broader, the elytral stria are sharper and a little larger and the dark colour on the head of *B. dallasi* is more extensive and not restricted to the basal margin as in most *B. wadeae*. The clearest separation is in the form and strength of the punctures on the head and pronotum. In *B. dallasi* these are moderately strong, sometimes a little longitudinally elongated but seldom confluent. In *B. wadeae* the pronotal punctures on the disc and those on the rear half of the head are strong, virtually confluent, longitudinally elongated to the extent that they form longitudinal grooves, particularly deep on the disc of the pronotum. In some *B. wadeae* there is also a longitudinal groove in the midline of the pronotum. The aedeagi of the two species are distinctive (Figs 3 & 4 and Watts 1987).

Distribution

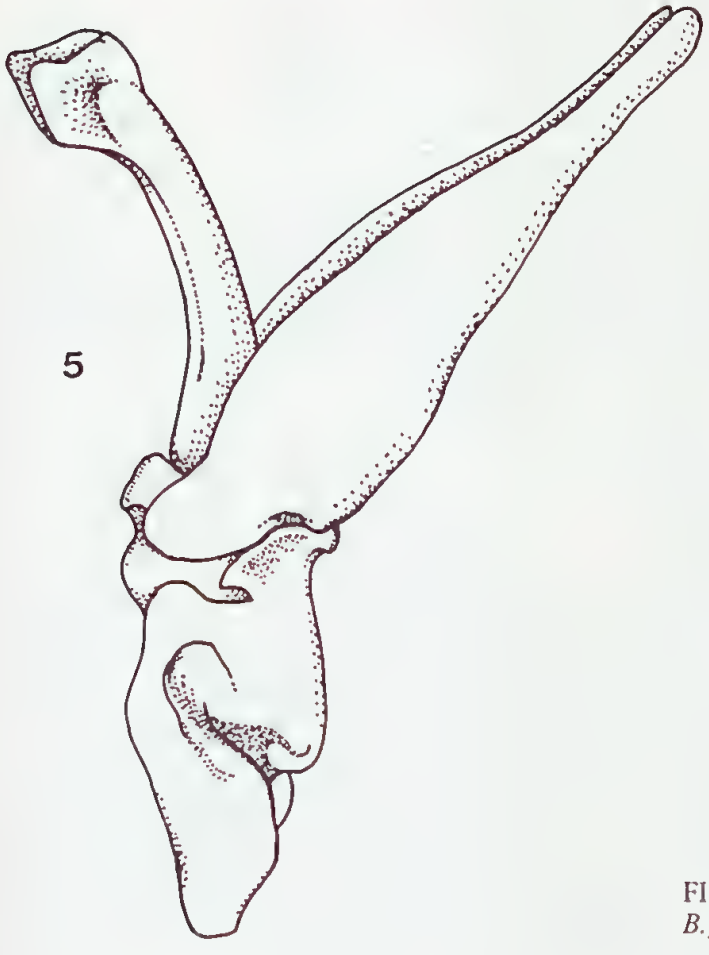
Known from Marree, Big Perry Springs, Clayton Crossing and Coward Springs, all localities in the southern Lake Eyre basin in South Australia.

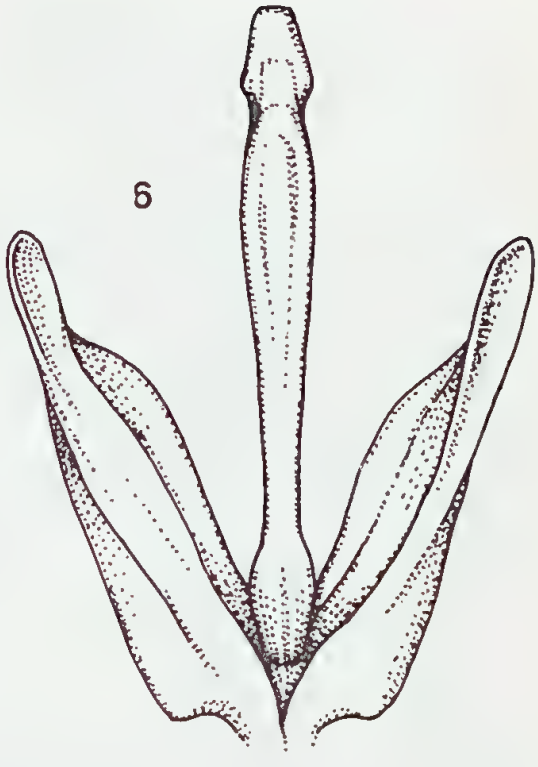


FIGURES 1 & 2. Lateral and ventral views of apical portion of aedeagus of *B. sarahae*.



FIGURES 3 & 4. Lateral and ventral views of aedeagus of *B. wadeae*.





FIGURES 5 & 6. Lateral and ventral views of aedeagus of *B. josephenae*.

Types

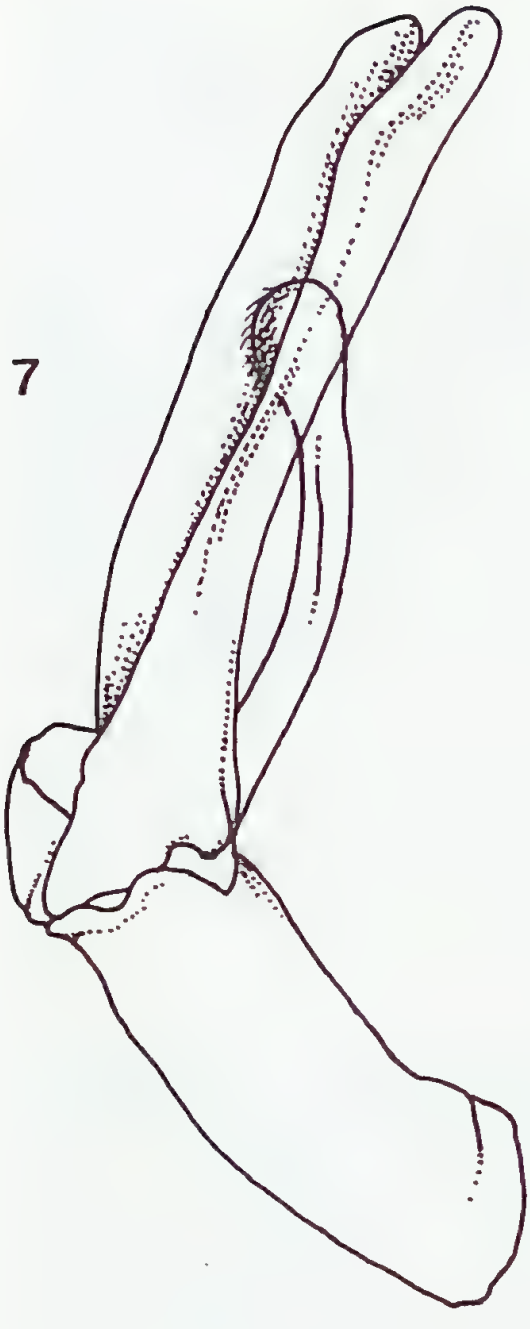
Holotype: Male. 'S. Aust. at light. Levi Crk. 8 km NW, Big Perry Springs. 28°, 19.2' 136°, 16.1, 7 Dec. 1974 J.A. Herridge'; in SAMA.

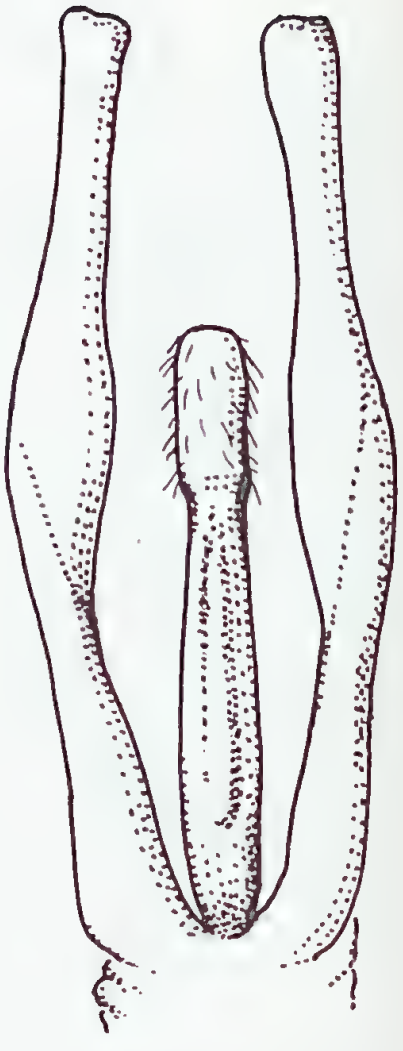
Paratypes: Eighteen, same data as Holotype, in SAMA; 1, 'S. Aust. at light. Marree Racecourse. 1 Dec. 1974. J.A. Herridge'; 5, 'Clayton Crossing, S.A. 13 November 1955. At light. E. T. Giles'; 1, 'S. Aust. Coward Springs. At light. 9 Nov. 1965, G. F. Gross', all in SAMA.

Berosus sarahae sp. nov.
(Figs 1, 2)

Description (number examined, 11)

Length 3.5 – 4.5 mm. Oval, widest in the middle of the elytra. Elytra not, or only weakly, humped. Apex of elytron bluntly pointed. Head relatively broad, red-brown, lighter towards the front. Pronotum red-brown, with two broad longitudinally darker bands in the middle. Elytra red-brown, sutural lines dark brown-black, more marked on disk than on sides, several poorly marked dark spots, the most prominent near sutural line behind middle. Ventral surface and appendages light red-brown. Punctures on head strong, moderately dense, those on front of head denser but not much smaller than those on the rest of the head. Pronotal punctures moderately and rather evenly covered with moderate sized punctures, stronger and denser laterally, a narrow central longitudinal strip impunctate. Pronotum covered with a fine reticulation. Elytral striae grooved, strial punctures, moderately distinct, longer and sparser towards the sides, the groove sharply defined only on inner edge. Interstrial punctures much smaller than those in adjacent striae, relatively sparse and shallowly impressed. Second elytral striae often lacking groove (as does adjacent basal portion of first stria), consisting of an unevenly spaced row of 5–10 serial punctures some of which may be joined. Elytra covered with a fine reticulation as on pronotum. Metacoxal plates and abdominal sterna covered with strong, dense, rugose punctures. Midline of mesosternum with strongly raised keel, ventral edge flat and slightly concave. Midline of first abdominal sternite keeled. Front edge of metacoxal plates quite strongly ridged. Metacoxal process produced





FIGURES 7 & 8. Lateral and ventral views of aedeagus of *B. sonjae.*

backwards into small spine in midline, central lobes raised, weakly diverging anteriorly, small oval to diamond shaped impunctate depression in midline. Rugose portion of metafemur half to two thirds length of femur, that of mesofemur about half the length and that of profemur a little less than half the length of femur. Apical abdominal sternite deeply and widely notched.

Male

Protarsi four segmented, first segment moderately expanded.

Remarks

The species clearly belongs in the *B. approximans* group of Australian *Berosus* by virtue of its general size and shape, strongly keeled mesosternum and first abdominal sternite, short second elytral striae and notched apical sternite in both sexes. It however lacks the black metallic head found in all other group members. Its light red-brown ventral surface and strong ventral punctures also separate it from other members of the group *(B. approximans* Fairmaire, *B. discolor* Blackburn, *B. juxtadiscolor* Watts, *B. reardoni* Watts and *B. timmsi* Watts*)* which all have dark-brown to black ventral surfaces and weaker ventral punctation.

Distribution

Kuranda and Cairns district, North Queensland.

The Cairns district specimens were taken at light, the Mt Molloy specimens in 100–300 cm deep water in a seasonal swamp.

Types

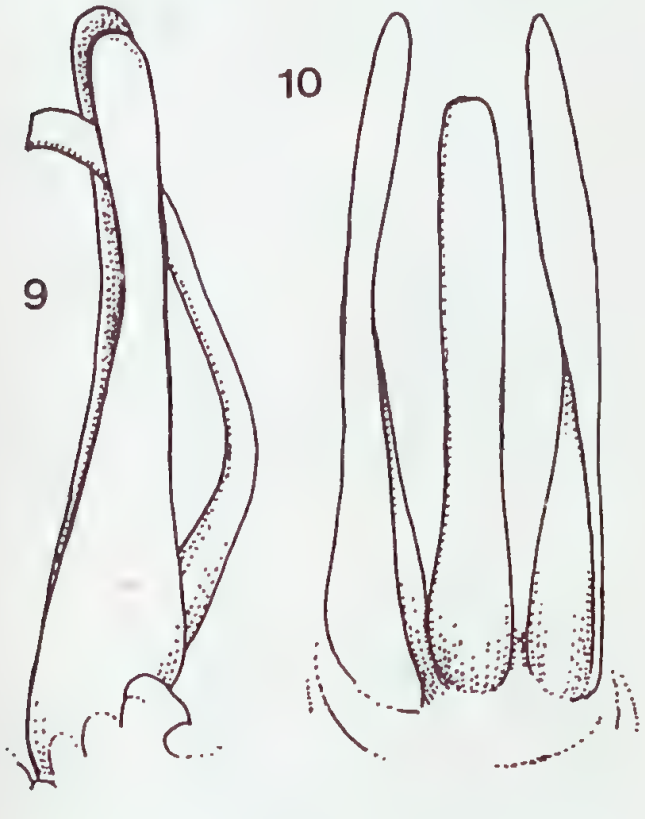
Holotype: Male. 'Cairns dist. A.M. Lea', in SAMA.

Paratypes: 9, same data as holotype, in SAMA; 1, 'Kuranda Queensland, Griffith Collection, Id by A.M. Lea', in SAMA; 7, '2 km N Mt Molloy, Qld, 30.3.96, C. Watts', in SAMA.

Berosus sonjae sp. nov.
(Figs 7, 8)

Description (number examined, 13)

Length, 4.5–5.5 mm. Elongate oval, not humpbacked, apex of elytron with strong outer spine, lacking inner spine. Elytron yellow-brown, portions of stria and punctures darker, stronger in a few places giving elytron two–three vague darker broad bands. Ventral surface, other than appendages darker, rugose portions of femora same yellow-brown colour as rest of leg. Punctures on head strong, those towards rear tending to form longitudinal rows in some specimens, weaker and sparser in front. Pronotum evenly covered with large, round, even-sized punctures most 1/4 and 1/2 a puncture width apart. Elytral striae well impressed, almost masking punctures in many places, punctures becoming much larger towards apex and sides, interstrial punctures setose, rather shallow particularly at sides where they become subobsolete, about half the size of those on pronotum, in most interstriae arranged in one loose row. Ventral surface densely rugose-punctate except for small diamond-shaped portion in centre of metasternum. Mesosterum with weak midline keel, metasternum with short, weak, midline keel anteriorly. Hind margin of apical (5th visible) sternite broadly and shallowly concave. Midline of first sternite weakly keeled in extreme front. Metacoxal process raised, triangular. Rugose portions of meso- and metafemur 2/3 to 3/4 length of femur, that on profemur somewhat less.



FIGURES 9 & 10. Lateral and ventral views of apical portion of aedeagus of *B. gibbae*.

Male

Protarsi four segmented, basal segment a little swollen, about length of second and third segments combined, second and third segments same length in dorsal view, third longer in lateral view, not enlarged, total length about equal to length of tibia. Male genitalia with short aedeagus (Figs 7 & 8).

Remarks

Berosus sonjae belongs to the section of Australian *Berosus* characterised by the lack of a strong mesosternal pillar, normal elytral punctation, and uniform and relatively large punctures on pronotum (*B. amoenus* Watts, *B. josephenae* Watts and *B. gibbae* Watts). It can be separated from all of these by the distinctive male genitalia which has the aedeagus much shorter than the parameres, the tips of which are truncated (Figs 5–10) (When I first saw the aedeagus I assumed I had damaged it in the extraction but further dissections proved this wrong). In addition to the difference in the male genitalia it can be separated from *B. amoenus* by its yellow-brown rather than black head; from *B. josephenae* by its lighter coloured femora, and by the lateral interstrial punctures which are hard to trace and often marked only by setae, whereas in *B. josephenae* they are large but shallow and almost twice the diameter of those on disc; from *B. gibbae* in being somewhat larger, with rather closer and more regular punctation on pronotum, lack of a well marked fine reticulation on elytra and its elytral striae tending to be more deeply impressed.

Distribution

Known only from the type locality in North Queensland. All specimens were taken at light.

Types

Holotype: Male. 'Qld. 70km SW Greenvale 16–28 Jan 95 A. J. Watts', in SAMA.

Paratypes: 4 same data as Holotype, in SAMA; 8 same data as Holotype except 15–24 Feb 95, in SAMA; 2, same data as holotype except 29 Dec – 13 Jan 96, in SAMA.

Acknowledgments

I would like to thank Rob Gutteridge for the excellent drawings, Vicki Wade and Robyn Cherrington for typing the manuscript.

Reference

WATTS, C. H. S. 1987. Revision of Australian *Berosus* Leach (Coleoptera : Hydrophilidae). *Records of the South Australian Museum* **21**(1): 1–28.

NEW SPECIES OF *PEDIANA* (HETEROPODIDAE: ARANEAE) SIMON FROM CENTRAL AND NORTHERN AUSTRALIA.

DAVID B. HIRST

HIRST, D. B. 1996. New species of *Pediana* (Heteropodidae: Araneae) Simon from central and northern Australia. *Records of the South Australian Museum* **29**(2): 153–164.

Four new species of *Pediana* Simon, *P. longbottomi*, *P. paradoxa*, *P. temmei* and *P. webberae*, are described from central and northern Australia. All exhibit characters which uniquely bond them as a further group within the genus *Pediana*. A new locality record for *P. regina* (L. Koch) and revised key to species are given.

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Manuscript received 1 March 1996.

The genus *Pediana* Simon, 1880 was revised by Hirst (1989) with the redescription of the four known Australian species and later Hirst (1995) described a further species from one female from south-western Northern Territory. Material received since from the Northern Territory Museum, the Western Australian Museum and other material discovered in or collected recently for the South Australian Museum collection, contained four more species of *Pediana* remarkably distinct from those previously known.

Pediana was considered (Hirst 1989) to have a relatively high convex carapace, a pointed dorsal ridge on the male tibial apophysis, and female spermathecal sacs, when present, extended posteriorly under the fossa. Unique characters found in the new species, males sometimes lacking a pointed dorsal ridge on the tibial apophysis, a low posterior carapacial area sometimes present in the female, anteriorly directed spermathecal sacs of known females and spinnerets positioned subapically on a more elongate abdomen of all species have necessitated amendments to the generic diagnosis (see below). A new group, the *webberae* group, is erected for the new species and contains two species-pairs.

Materials And Methods

Leg indices are leg length excluding coxa and trochanter divided by length of carapace. The penultimate stage and poor condition of the male of *P. webberae* do not allow for adequate comparative measurements and these are kept to a minimum. Other materials and methods are given in Hirst (1989, 1991). Abbreviations. *Institutions*: **NTM**, Northern Territory Museum; **SAMA**, South Australian Museum, Adelaide; **SMF**, Natur-Museum Senckenberg, Frankfurt, Germany; **WAM**, Western Australian Museum, Perth. *Morphology*: AE, anterior eyes; PE, posterior eyes; MOQ, median ocular quadrangle; L or l, length; W, width. Other abbreviations used in description are standard for the Araneae.

Systematics

Genus *Pediana* Simon

Pediana Simon, 1880: 258. For full synonymy list see Hirst 1989: 113.

Diagnosis

Carapace relatively high; flat above and declivity posterior to fovea or rarely with declivity anterior of fovea. ALE largest, occasionally males with AME largest; AE row recurved, PE row procurved; lateral eyes raised on low common mound; MOQ longer than wide or occasionally wider than long. Legs 2143 or 1243, anterior pairs being subequal. Abdomen oval with spinnerets apical or elongate and reaching more than twice as long as wide, obtusely pointed posteriorly with spinnerets subapical at least in females. Male palp with embolus coiled once or two and a half or five times, coil stack wide and of low profile. Palpal tibia with large retrolateral distal apophysis having a raised dorsal basal ridge or ridge not raised but extended dorsally on tibia. Spermathecal sacs projecting to posterior or to anterior, or absent.

Revised Key To Species Of *Pediana* Of Australia

Female

1 — Abdomen elongate, bluntly pointed posterior, spinnerets subapical (Fig. 3) 2
— Abdomen oval, rounded posterior, spinnerets apical 4

2 — Carapace relatively flat; spermathecal sacs originate from posterior of fertilization duct 3
— Carapace with steep declivity anterior of fovea; spermathecal sacs originate anterior of fertilization duct ..... *webberae*, sp. nov.

3 — Dorsal carapacial and abdominal stripe lacking (Fig. 15) ..... *temmei*, sp. nov.
— Dorsal carapacial and abdominal stripe present (Fig. 20) ..... *paradoxa*, sp. nov.

4 — Anterior tibiae usually with 1 dorsal spine and 2 ventral spine pairs; insemination ducts lightly sclerotised with 2–4½ coils, spermathecal sacs present 5
— Anterior tibiae usually with 2 dorsal spines and 3 ventral spine pairs; insemination ducts heavily sclerotised with 5 coils, spermathecal sacs absent 7

5 — Venter of abdomen with yellow setae, bases of femora not black ventrally 6
— Venter of abdomen with orange setae, bases of femora black ventrally ..... *regina* (L. Koch)

6 — Leg femora conspicuously spotted, legs and body with variably coloured setae, epigynum small, insemination ducts with 2½ coils .... *occidentalis* Hogg
— Leg femora inconspicuously spotted, legs and body with yellow-white setae, epigynum relatively large, insemination ducts with 4½ coils ..... *mainae* Hirst

7 — Anterior femora with white spots; epigynum broad posteriorly ..... *horni* Hogg
— Anterior femora reddish ventrally; epigynum narrows posteriorly ..... *tenuis* Hogg

Male

1 — Embolus with 1–1¼ coils 2
— Embolus with 2½ coils or more 3

2 — Carapace 3–4x longer than high with slight declivity anterior of fovea (Fig. 7); tibial apophysis with raised dorsal ridge (Fig. 9) ..... *webberae*, sp. nov.
— Carapace 5x longer than high, flat (Fig. 10); tibial apophysis lacking raised dorsal ridge at base of apophysis (Fig. 13) ..... *longbottomi*, sp. nov.

3 — Embolus with 2½– 2¾ coils 4
— Embolus with 5 coils 7

4 — Abdomen elongate (L = 2x W); median apophysis extends away from base of embolus (Fig. 18) 5
— Abdomen rounded or oval (L = 1½x W); median apophysis adjacent base of embolus (Hirst 1989; fig. 6) 6

5 — Dorsal carapacial and abdominal stripe lacking; dorsal ridge of tibial apophysis with apex curved (Fig. 19) ..... *temmei*, sp. nov.
— Dorsal carapacial and abdominal stripe present; dorsal ridge of tibial apophysis with apex straight (Fig. 25) ..... *paradoxa*, sp. nov.

6 — Embolic base with small median apophysis ..... *regina* L. Koch
— Embolic base with broad median apophysis ..... *occidentalis* Hogg

7 — Dorsal ridge of tibial apophysis with apex curved ..... *horni* Hogg
— Dorsal ridge of tibial apophysis with apex straight ..... *tenuis* Hogg

Pediana webberae, sp. nov.
(Figs 1–9, 26; Table 1)

Types

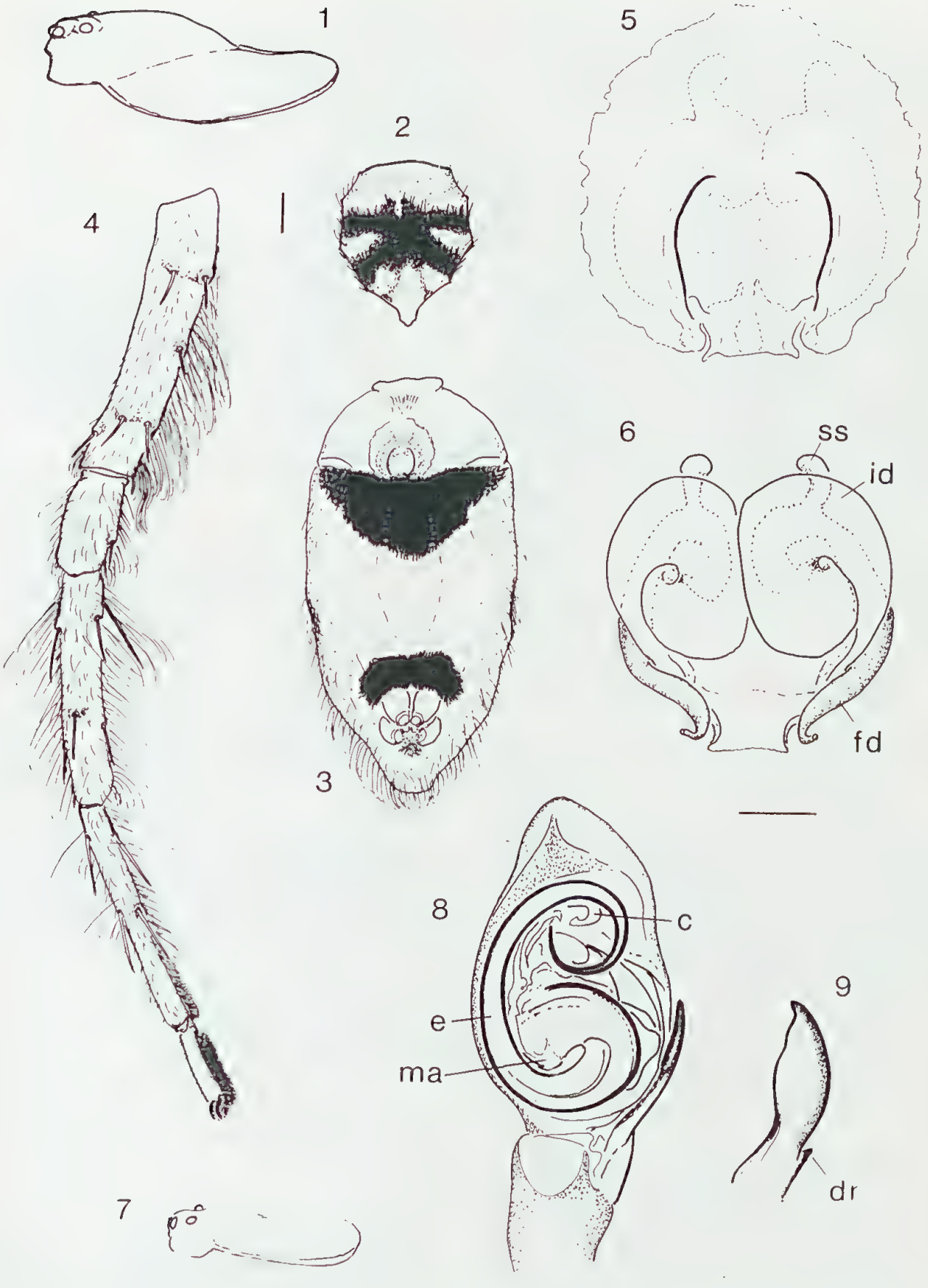
Holotype ♀; Darwin, (12°27'S 130°50'E), Northern Territory, Dec. 1992, J. Webber, NTM A–81.

Non-type

♂, no data, SAMA N1994649.

Diagnosis

Colour and pattern typical for *Pediana* species. Carapace with declivity anterior of fovea; AME of male may be largest; posterior eyes relatively small, subequal; MOQ wider than long. Leg spine bases raised on low mound at least on femora;



FIGURES 1–9. *Pediana webberae*, sp. nov. 1–6, holotype female. **1**, carapace, lateral; **2**, sternum; **3**, abdomen, venter; **4**, leg IV, right dorsal; **5**, epigynum, cleared; **6**, vulva, dorsal. 7–9, male. **7**, carapace, lateral; **8**, left palp cymbium and tibia, ventral; **9**, tibial apophysis, retrolateral. Scale lines; Figs 1–4, 7, 1mm, Figs 6, 8, 9, 0.5mm. c, conductor; dr, dorsal ridge; e, embolus; fd, fertilization duct; id, insemination duct; ma. median apophysis; ss, spermathecal sac.

posterior legs with brushes of long setae proventrally. Male embolus with just over 1 complete coil. Female epigynum relatively large, spermathecal sacs project anteriorly, insemination ducts with 1¼ lightly sclerotised coils.

Description

Female. CL 7.48, CW 7.47. AL 9.15, AW 4.90.

Colour in alcohol: Carapace red-brown, striae darker, numerous short black setae; caput dark in ocular area, white and yellow setae; clypeus with orange setae. Chelicerae red-brown, long yellow setae, basal half with short white setae. Maxillae and labium black but anterior margin pale. Sternum; anterior orange with long orange setae, medially with black 'x' pattern (Fig. 2), posterior tip yellow. Legs yellow, femora I–III ventrally with 2 rows of white spots formed of short adpressed setae; posterior legs with numerous long setae on tibia III, femur, tibia and metatarsi IV. Abdomen dorsum and venter (Fig. 3) typical.

Eyes: AME 0.48. AME: ALE: PME: PLE = 1: 1.04: 0.67: 0.69. Interspaces; AME–AME 0.65, AME–ALE 0.50, PME–PME 1.98, PME–PLE 1.69, AME–PME 1.35, ALE–PLE 1.21. MOQ, aw: pw: l = 2.65: 3.31: 3.02. Width of clypeus to AME 0.61.

Labium: L 1.02, W 1.47. Sternum: L 3.79, W 3.08.

Legs: (Table 1) Anterior leg indices; I = 3.6, II = 3.5.

Spination: As for the *P. horni* group but, tibiae III and IV have 2 dorsal spines, tibia IV lacks the distal ventral spine pair.

Epigynum: Lateral rim rounded anteriorly; anterior of fossa recessed. Vulva with small spermathecal sacs projecting from anterior of fertilization duct (Fig. 5), insemination ducts with 1¼ lightly sclerotised coils (Fig. 6).

Male. CL 4.78, CW 4.41. AL 7.65, AW 3.00.

Outer skin lifted in readiness for the sloughing process. Most setae lost from outer skin. Caput lower with only a gradual declivity to fovea (Fig. 7); AME appear largest on adult skin but asymmetrical due to softness; posterior of abdomen less rounded than in the female, extending in a point beyond spinnerets; leg femora not as obviously tuberculate.

Colour in alcohol: As in female but faded. Corresponding areas of black on female are brown on the male.

Palps: Unhardened pre-moult condition, although fully formed under epidermis final shape and position of various sclerites within cymbium may not be complete; conductor originates prodistally as in the *regina* group but instead of having two coils is short with a curled tip; embolus with a little over 1 coil (Fig. 8); tibial apophysis more than 2x length of tibia, broad with straight pointed dorsal ridge on base (Fig. 9).

TABLE 1. Leg measurements of *Pediana webberae*, sp. nov. Values are for holotype female

	Leg 1	Leg 2	Leg 3	Leg 4	Palp
Femur	8.12	8.09	5.79	7.64	2.85
Patella	3.24	3.23	2.62	2.71	1.42
Tibia	6.45	6.29	4.78	5.69	1.51
Metatarsus	6.58	6.22	3.89	5.88	–
Tarsus	2.21	2.14	1.73	1.96	2.20
Total	26.60	25.97	18.81	23.88	7.98

Distribution

Known only from Darwin, Northern Territory (Fig. 26).

Remarks

The male is excluded from the type material. It is assumed to have been collected at the beginning of this century and is in poor condition. It is penultimate but removal of the outer epidermis reveals a soft, yet apparently fully formed adult beneath. Although the carapace shape and tuberculate leg femora closely associate the male with the female of *P. webberae* it is not unequivocally conspecific. The male of *P. webberae* differs from *P. longbottomi* in the carapace shape, the tuberculate leg femora, in having a pointed dorsal ridge at the base of a broader palpal tibial apophysis and smaller venter badge markings. *P. webberae* further differs from *P. temmei* and *P. paradoxa* in the male embolic coils and female spermathecal sacs.

Etymology

The species is named after Ms J. Webber (NTM), collector of the holotype.

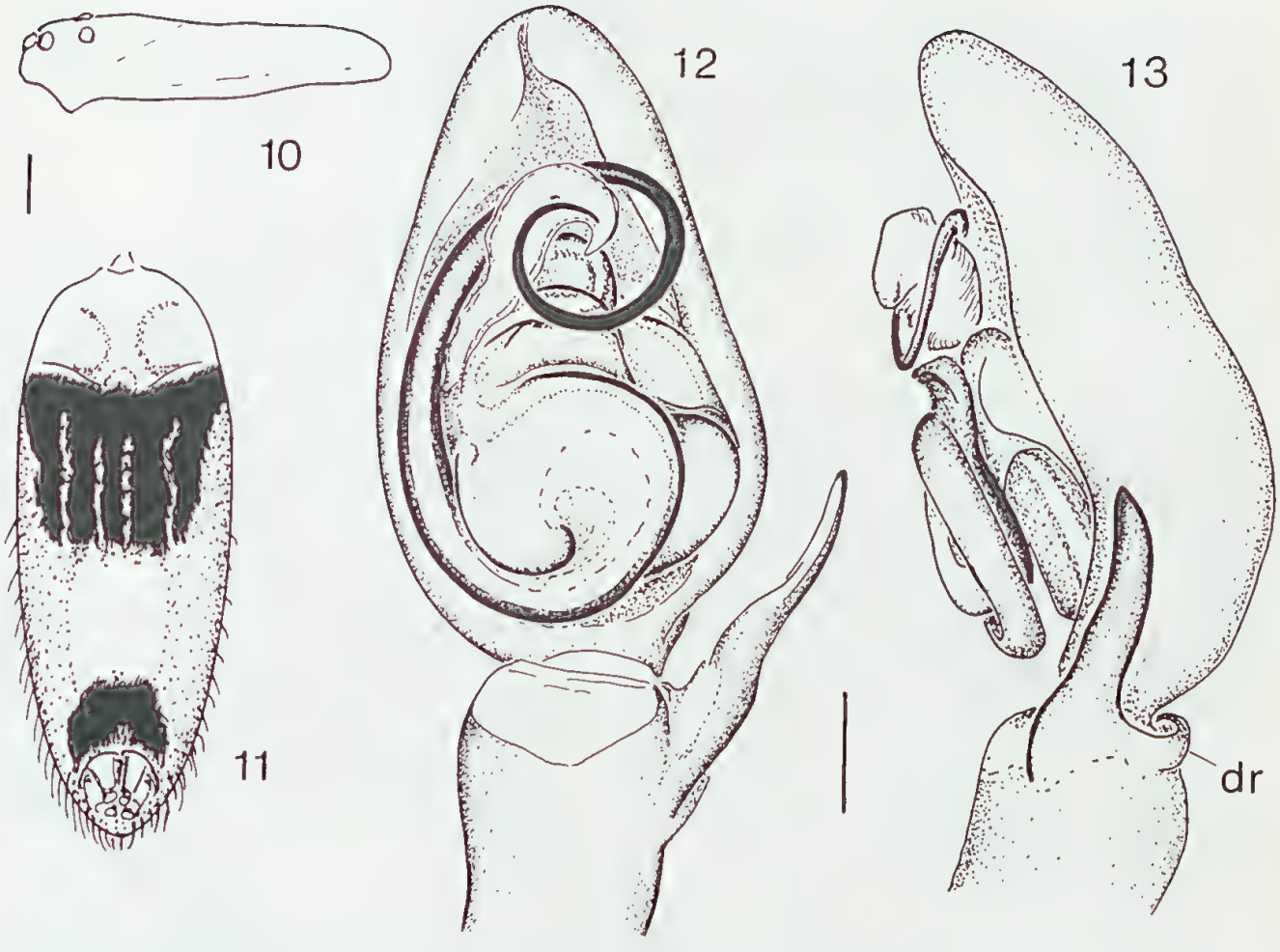
Pediana longbottomi, sp. nov.
(Figs 10–13, 26; Table 2)

Type

Holotype ♂, Drysdale River Stn (15°42'S 126°22'E), Xavier River area, Western Australia, 8–12.ix.1993, A.F. Longbottom (S.1366), WAM 94/1673.

Non-types

Juvenile, same data as holotype but (S.1367),



FIGURES 10–13. *Pediana longbottomi*, sp. nov. Male. **10**, carapace, lateral; **11**, abdomen, venter; 12–13, left palp cymbium and tibia, **12**, ventral; **13**, retrolateral. Scale lines; Figs 10–11, 1mm, Figs 12–13, 0.5mm. dr, dorsal ridge.

WAM 94/1675; juv., same data as holotype but Diamond Waterhole, 1.viii.1993, amongst vegetation, (S.1311), WAM 94/1674.

Diagnosis

Male: Colour and pattern typical for *Pediana* species but venter with large black patches. Carapace flat. AME largest, PME relatively small. Leg femora not conspicuously tuberculate. Tibial apophysis relatively narrow with long low ridge extending to dorsal of tibia; embolus with 1¼ coil. Female unknown.

Description

Male. CL 6.03, CW 4.91. AL 8.92, AW 3.74.

Colour in alcohol: Carapace and chelicerae red-brown, short black, grey and orange setae, adpressed on carapace, upright on chelicerae. Maxillae and labium dark brown. Sternum dark brown but posterior tip pale. Legs brown; brown-black stout setae and adpressed fine white setae; spines on femora short, weak. Abdomen dorsally typical; venter with large black patches (Fig. 11).

Eyes: AME 0.42. AME: ALE: PME: PLE = 1: 0.95: 0.69: 0.79. Interspaces; AME–AME 0.36, AME–ALE 0.07, PME–PME 0.98, PME–PLE 1.26, AME–PME 1.02, ALE–PLE 1. MOQ, aw: pw: l = 2.36: 2.36: 2.71. Width of clypeus to AME 0.60.

Labium: L 0.92, W 1.08. Sternum: L 3.01, W 2.43.

Legs: (Table 2) Anterior leg indices; I = 5.6, II = 5.5.

TABLE 2. Leg measurements of *Pediana longbottomi*, sp. nov. Values are for holotype male

	Leg I	Leg 2	Leg 3	Leg 4	Palp
Femur	10.08	9.92	6.89	9.78	2.16
Patella	3.16	3.13	2.43	2.55	1.03
Tibia	9.03	9.04	6.19	8.09	1.22
Metatarsus	8.81	8.45	5.06	8.82	–
Tarsus	2.60	2.75	1.82	2.27	2.34
Total	33.68	33.29	22.39	31.51	6.75

Spination: As for the *P. horni* group, but tibia IV lacking the distal ventral spine pair.

Palps: Embolus with 1¼ coil (Fig. 12), embolic base with high distal ridge; tibial apophysis with low ridge extending to dorsal of tibia (Fig. 13).

Distribution

Known only from Drysdale River Station in Western Australia (Fig. 26).

Remarks

P. longbottomi differs from all known male *Pediana* in lacking a sharply raised dorsal ridge to the tibial apophysis base. It further differs from *P. webberae* in the male tibial apophysis being narrower, in having the embolic base extended distally and larger ventral abdominal black patches. In the male of *P. longbottomi* the posterior of the abdomen (Fig. 11) is less extended and the legs are not so markedly tuberculate as in *P. webberae*. However, two juveniles from the same locality possess those characters indicating that they may also be present in the female *P. longbottomi*. Those juveniles do not have a high caput with steep declivity anteriorly to fovea, nor do they possess brushes of setae on leg IV.

Etymology

The species is named after Mr A. F. Longbottom who collected the material.

Pediana temmei, sp. nov.
(Figs 14–19, 26; Table 3)

Types

Holotype ♂, 9.5 km SSE Ampeinna Hills, (27°09'S 131°09'E), South Australia, 22.iii.1995, D. Hirst, SAMA N19951.

Allotype ♀, 11.5 km SSW of Ampeinna Hills, (27°11'S 131°05'E), South Australia, 24.iii.1995, D. Hirst, SAMA N19952.

Paratypes; ♀, same data as allotype, SAMA N19953; 2 ♂, 10 km E of Ampeinna Hills, (27°05'S 131°13'E), South Australia, 23.iii.1995, D. Hirst, SAMA N19954–5.

Diagnosis

Colour grey or grey-black, venter of abdomen lacks conspicuous black patch anterior to spinnerets. Carapace highest posteriorly. ALE largest. Leg femora spines short except distally. Abdomen extended posteriorly beyond spinnerets in female. Male embolus with 2½ coils; dorsal ridge of tibial apophysis with curved apex. Female spermathecal sacs small, projecting anteriorly from beneath anterior sector of fossa; insemination ducts with 2¼ lightly sclerotised coils.

Description

Male. CL 4.34, CW 3.76. AL 4.31, AW 2.10.

Colour in alcohol: Carapace brown, ocular area darker, numerous uniform short black, white and orange setae. Chelicerae red-brown, long white setae. Maxillae and labium brown-black. Sternum; brown with black suffusion, grey setae. Coxae and most part of legs yellow–brown with black suffusion, legs III darker; anterior femora ventrally with white spots formed of short adpressed setae; long setae on legs not numerous. Abdomen somewhat shrunken; venter with black patch posterior to epigastric furrow, few black spots medially, suffusion anterior of spinnerets.

Eyes: AME 0.34. AME: ALE: PME: PLE = 1: 1.15: 0.82: 0.88. Interspaces; AME–AME 0.32, AME–ALE 0.12, PME–PME 1.12, PME–PLE 1.41, AME–PME 1.24, ALE–PLE 1.12. MOQ, aw: pw: l = 2.32: 2.76: 3.03. Width of clypeus to AME 0.59.

Labium: L 0.65, W 0.74. Sternum: L 2.14, W 1.78.

Legs: (Table 3) Anterior leg indices; 6.

Spination: As in *P. longbottomi* but 1 spine on anterior tibiae.

Palps: Embolus with 2½ coils (Fig. 18); tibial apophysis narrow, dorsal ridge with curved point on apex (Fig. 19).

Female. CL 6.41, CW 5.38. AL 9.96, AW 4.89.

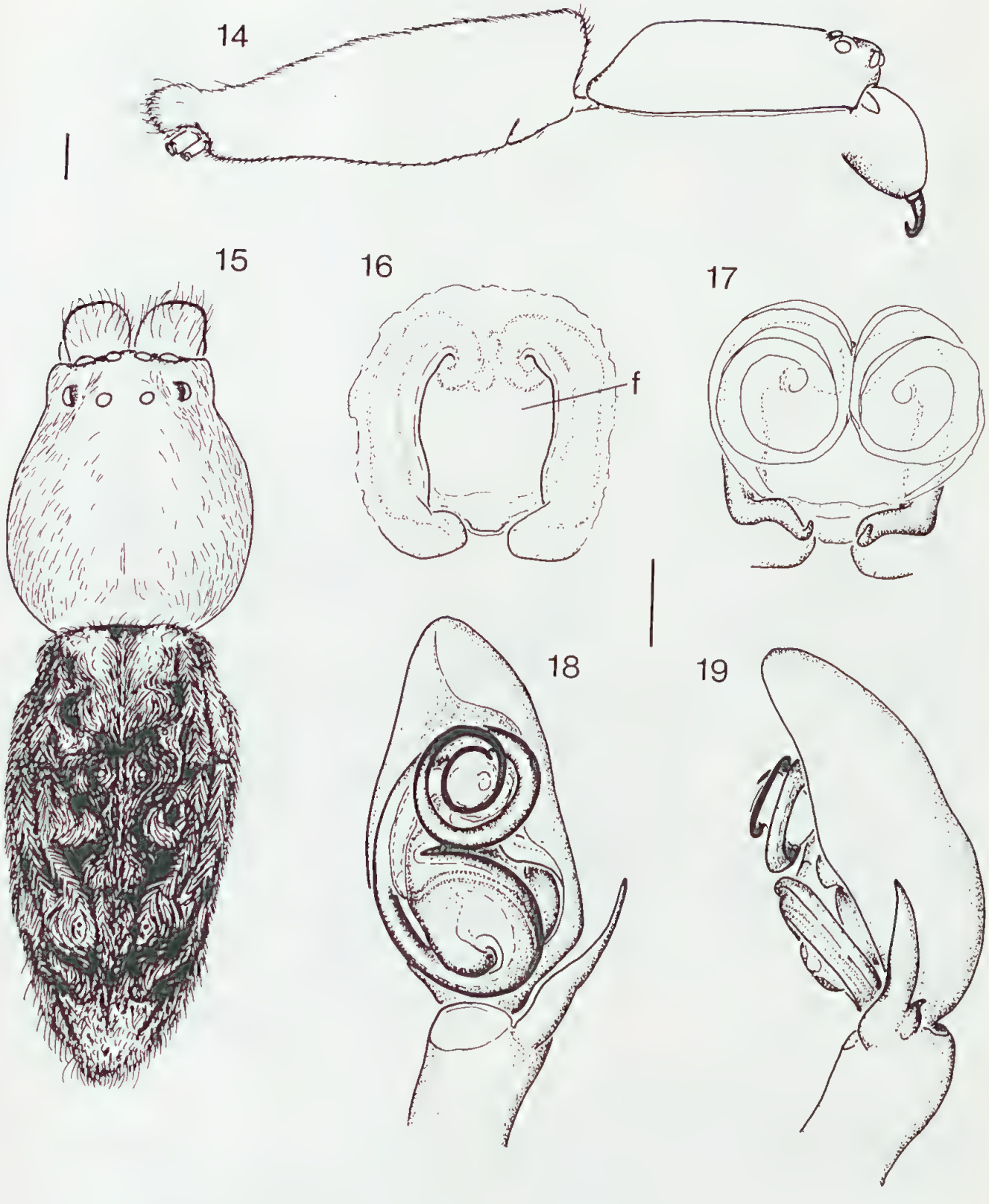
Colour in alcohol: As male but carapace with dense setae; white setae anterior to and posterior of AME. Chelicerae dark brown with short setae present on basal half. Maxillae and labium darker. Abdomen with dense short setae dorsally as on carapace but arranged in opposing directions to form a pattern (Fig. 15); venter with dull orange-brown badge with larger black patch posterior to epigastric furrow and more spots of black setae.

Eyes: AME 0.44. AME: ALE: PME: PLE = 1: 1.20: 0.91: 0.91. Interspaces; AME–AME 0.41, AME–ALE 0.18, PME–PME 1.18, PME–PLE 1.55, AME–PME 1.39, ALE–PLE 1.23. MOQ, aw: pw: l = 2.41: 3.00: 3.23. Width of clypeus to AME 0.73.

Labium: L 1.00, W 1.23. Sternum: L 2.94, W 2.38.

Legs: (Table 3) Anterior leg indices; 3.4.

Spination: As male but patellae III and IV lack a prolateral spine.



FIGURES 14–19. *Pediana temmei*, sp. nov. 14–15, female abdomen and carapace, **14**, lateral, **15**, dorsal; 16–17, female epigynum, **16**, cleared, ventral, **17**, vulva, dorsal; 18–19, male, left palp cymbium and tibia, **18**, ventral; **19**, retrolateral. Scale lines; Figs 14–15, 1mm, Figs 16–19, 0.5mm. f, fossa.

Epigynum: Fertilization ducts sharply bent posteriorly (Fig. 17). Vulva with small spermathecal sacs rising from fertilization duct just under anterior margin of fossa and projecting anteriorly (Fig. 16), insemination ducts with 2¼ lightly sclerotised coils (Fig. 17).

TABLE 3. Leg measurements of *Pediana temmei*, sp. nov. Values are for holotype male with allotype female in parentheses

	Leg I	Leg 2	Leg 3	Leg 4	Palp
Femur	7.96 (6.78)	7.91 (6.79)	5.48 (4.74)	7.95 (6.89)	1.62 (2.15)
Patella	2.29 (2.69)	2.29 (2.72)	1.78 (2.13)	1.93 (2.22)	0.76 (1.11)
Tibia	6.73 (5.12)	6.71 (5.16)	4.19 (3.40)	6.16 (4.81)	0.88 (1.27)
Metatarsus	6.99 (5.28)	6.80 (5.11)	4.04 (3.29)	7.14 (5.35)	– –
Tarsus	2.01 (1.69)	2.02 (1.70)	1.43 (1.25)	1.82 (1.70)	1.83 (2.08)
Total	25.98 (21.56)	25.73 (21.48)	16.92 (14.81)	25.00 (20.97)	5.09 (6.61)

Variation

Carapace length of paratype males, 4.59 and 4.23; of paratype female 6.15.

Distribution

Known only from undulating sandplain country of the Great Victoria Desert in north-western South Australia (Fig. 26).

Remarks

Male *P. temmei* lack a posteriorly extended abdomen, while that of the female is only slightly extended (Fig. 14). *P. temmei* differs from all other *Pediana* species in lacking a 'typical' dorsal stripe. *P. temmei* is similar to *P. horni* in having a curved apical point on the dorsal ridge at the base of the male tibial apophysis but differs in embolic coiling as well as abdomen pattern.

Etymology

The specific epithet is used in recognition of the assistance and generosity given to the Arachnology Section by Dr Paul Temme, a member of the Waterhouse Club which supports the South Australian Museum.

Pediana paradoxa, sp. nov.
(Figs 20–26; Table 4)

Types

Holotype ♂, in *Hakea* nr rockhole, 18.5 km WNW Ungarinna Rockhole, (26°56'S 131°29'E), South Australia, 15.iii.1995, D. Hirst, SAMA N19956.

Allotype ♀, same data as holotype, SAMA N19957.

Diagnosis

Colour grey with black dorsal striping, venter lacks black patch anterior of spinnerets. Carapace highest posteriorly. ALE largest. Abdomen extended posteriorly beyond spinnerets. Male embolus with 2½ coils; dorsal ridge of tibial apophysis with straight apex. Female spermathecal sacs small, projecting anteriorly from just outside anterior margin of fossa; insemination ducts with 2¾ lightly sclerotised coils.

Description

Male. CL 4.22, CW 3.78. AL 6.26, AW 2.70.

Colour in alcohol: Carapace brown, ocular area darker, numerous short black setae form a stripe medially, narrowly divided anteriorly by grey setae; laterals with adpressed grey-white setae. Chelicerae red-brown, long white setae. Maxillae and labium brown with dark brown suffusion. Sternum brown with darker suffusion, grey-white setae. Coxae and most parts of legs yellow-brown with blackish suffusion, legs III darker with numerous short black setae; anterior femora ventrally with white spots formed of short adpressed setae. Abdomen grey with numerous grey-white and golden setae. Black setae form a dorsal stripe broken medially and then wedge-shaped interspersed with golden setae; venter badge area yellow with black patch posterior to epigastric furrow, few grey spots medially, black suffusion anterior of spinnerets, patches of black and pale red suffusion lateral to badge area.

Eyes: AME 0.33. AME: ALE: PME: PLE = 1: 1.12: 0.85: 0.85. Interspaces; AME–AME 0.33, AME–ALE 0.09, PME–PME 1.27, PME–PLE 1.36, AME–PME 1.30, ALE–PLE 1.06. MOQ, aw: pw: l = 2.33: 2.97: 3.09. Width of clypeus to AME 0.67.

Labium: L 0.59, W 0.72. Sternum: L 2.14, W 1.78.

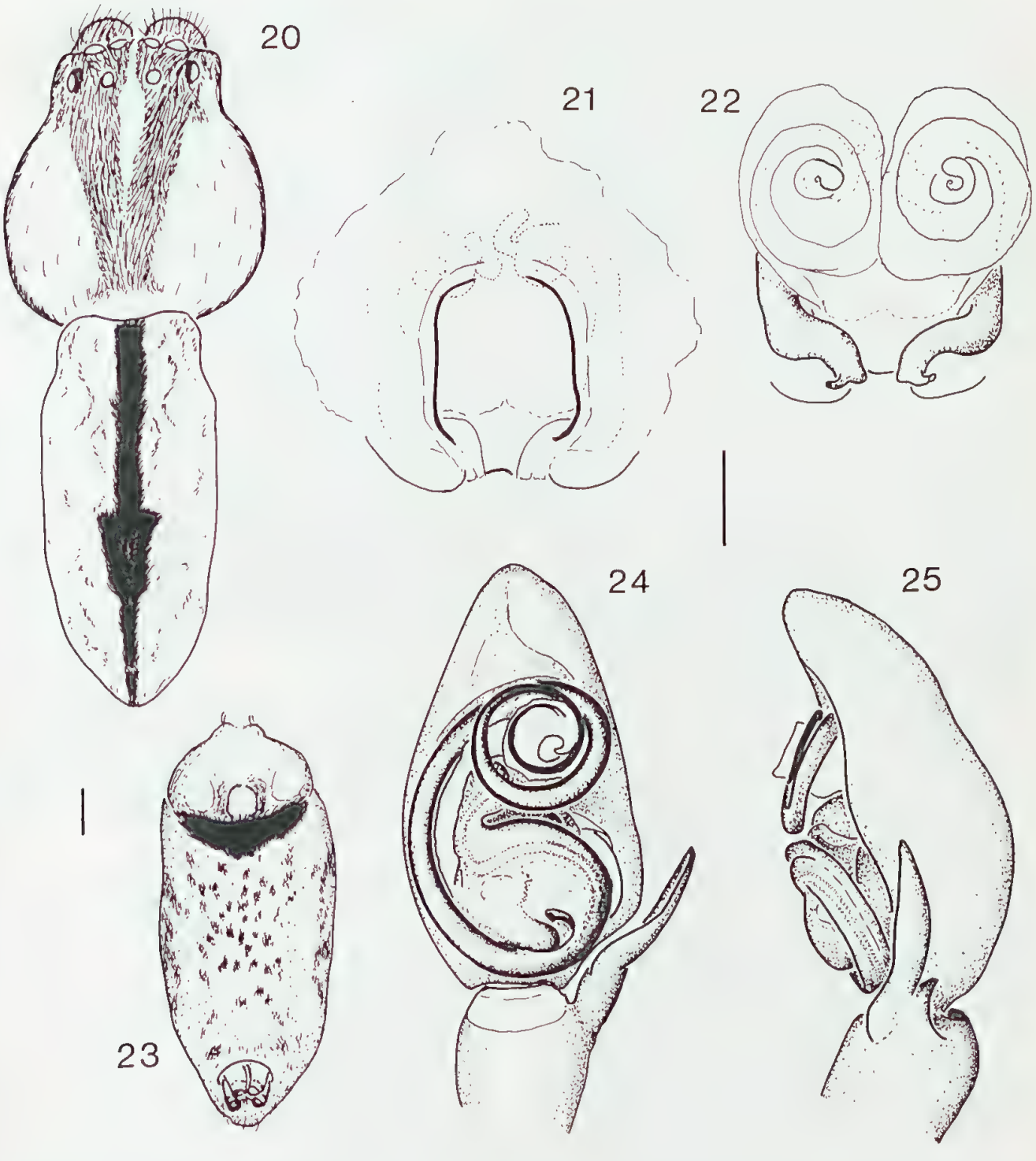
Legs: (Table 4) Anterior leg indices; 6.

Spination: As in *P. longbottomi* but patella IV lacks prolateral spine.

Palps: Embolus with 2½ coils (Fig. 24); tibial apophysis narrow, dorsal ridge with straight pointed apex (Fig. 25).

Female. CL 5.99, CW 5.28. AL 8.30, AW 3.75.

Colour in alcohol: As male but carapace with dense setae. Chelicerae with short orange setae on



FIGURES 20–25. *Pediana paradoxa*, sp. nov. **20**, female abdomen and carapace, dorsal; **21**, female abdomen, venter; 22–23, female epigynum, **22**, cleared, ventral, **23**, vulva, dorsal; 24–25, male, left palp cymbium and tibia. **24**, ventral; **25**, retrolateral. Scale lines; Figs 20–21, 1mm, Figs 22–25, 0.5mm.

basal half. Maxillae and labium brown with black suffusion. Abdomen (Fig. 20) with more numerous golden setae; venter with shiny black setae posterior to epigastric furrow; mixed white and red setae and spots of black setae (Fig. 21).

Eyes: AME 0.39. AME: ALE: PME: PLE = 1: 1.33: 0.92: 0.92. Interspaces; AME–AME 0.51, AME–ALE 0.02, PME–PME 1.31, PME–PLE 1.85, AME–PME 0.51, ALE–PLE 0.52. MOQ, aw: pw: l = 2.51: 3.15: 3.26. Width of clypeus to AME 0.77.

Labium: L 0.92, W 1.13. Sternum: L 2.82, W 2.23.

Legs: (Table 4) Anterior leg indices; 3.5.

TABLE 4. Leg measurements of *Pediana paradoxa*, sp. nov. Values are for holotype male with allotype female in parentheses

	Leg I	Leg 2	Leg 3	Leg 4	Palp
Femur	7.71 (6.83)	7.72 (6.82)	5.17 (4.72)	7.86 (6.94)	1.68 (2.03)
Patella	2.23 (2.64)	2.21 (2.61)	1.74 (2.09)	1.79 (2.10)	0.66 (1.05)
Tibia	6.76 (5.29)	6.65 (5.25)	4.01 (3.48)	6.04 (4.91)	0.89 (1.24)
Metatarsus	6.74 (4.87)	6.62 (4.88)	3.79 (3.03)	6.97 (5.31)	– –
Tarsus	1.83 (1.53)	1.81 (1.55)	1.40 (1.38)	1.82 (1.52)	1.74 (1.95)
Total	25.27 (21.16)	25.01 (21.11)	16.11 (14.70)	24.48 (20.78)	4.97 (6.27)

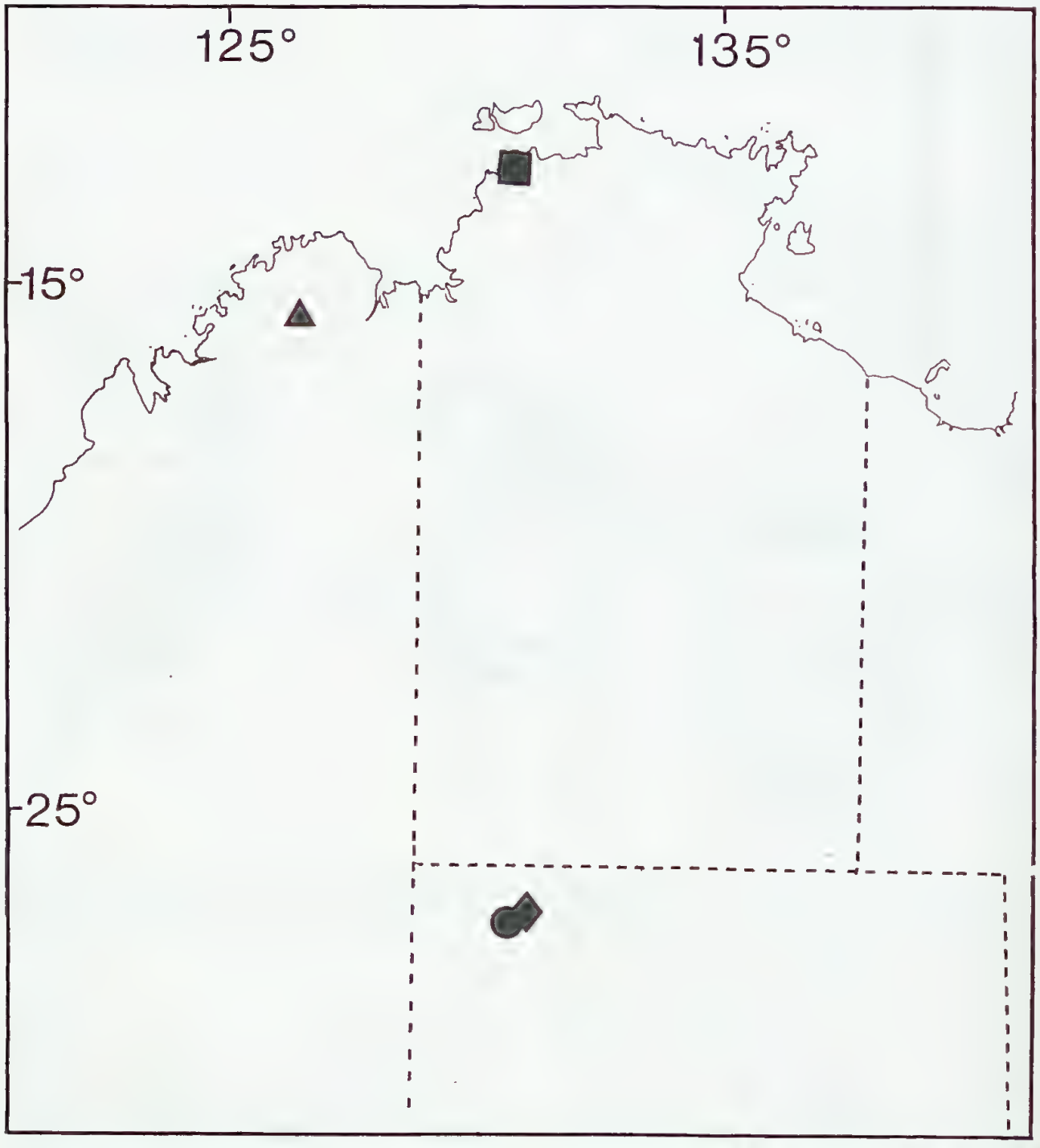


FIGURE 26. Distribution of species of the *Pediana webberae* group: *P. webberae* ■; *P. longbottomi* ▲; *P. temmei* ●; *P. paradoxa* ♦.

Spination: As male but tibia II with 1 dorsal spine and patella IV with prolateral spine.

Epigynum: Similar to *P. temmei* but narrower; vulva with longer spermathecal sacs (Fig. 22), insemination ducts with 2¾ lightly sclerotised coils (Fig. 23).

Distribution

Known only from undulating sandplain country of the Great Victoria Desert in north-western South Australia (Fig. 26).

Remarks

P. paradoxa is most similar to *P. temmei* from which it differs in colour, in the male tibial apohysis having a straight-edged triangular shaped apex to the dorsal ridge, in the embolic base and female spermathecal sacs. Both *P. paradoxa* and *P. temmei* could be confused with *P. occidentalis* which has similar coiling of the male embolus and female insemination ducts, but *P. occidentalis* has an oval shaped abdomen, apical spinnerets, differences in the male embolic base and large posteriorly directed female spermathecal sacs.

Etymology

The specific epithet is taken from the Latin (paradox) and reflects both the puzzling similarity between this species and *P. temmei* and their 'side-by-side' distribution.

Pediana regina L. Koch

New Record

♀, W.A., King David River area, Drysdale River Stn (15°42'S 126°22'E), 15.viii.1993, A.F. Longbottom (S.1282), on tree, WAM 94/1695.

Apart from the longer spermathecal sacs of this female it cannot be separated from *P. regina*. All previous records are from eastern Australia, however Strand (1913) described a male and a penultimate female as a variety from Central Australia. Hirst (1989) placed those specimens in *P. horni* (Hogg) based on the description given by Strand. The specimens (in SMF) have since been seen and indeed belong to *P. horni*.

Discussion

The female of *P. webberae* has a relatively high caput, as is usual for previously known species of the genus, but which differs markedly in having a steep declivity to a low cephalic portion (Fig. 1), a modification of the cephalothorax unknown in an Australian heteropodid. However, the carapace of the male *P. webberae* has but a gradual declivity (Fig. 7) more comparable with that of its sister-species, *P. longbottomi* (Fig. 10). Forward projection of the spermathecal sacs in the female is not uncommon in the heteropodids as it occurs in *Zachria* L. Koch (Hirst 1991) and *Typostola* Simon (Hirst in prep.). However, in those species the spermathecal sacs originate from the fertilization ducts after the latter have curved into the fossa cavity and rise from the posterior side of the curve. The spermathecal sacs then arc to the anterior. While the spermathecal sacs of *P. temmei* and *P. paradoxa* rise from the fertilization ducts as they curve under the fossa (Figs 16, 22) nearer to the 'normal' position seen in most Australian Deleninae genera which possess spermathecal sacs, in *P. webberae* the spermathecal sacs originate before the fertilization ducts curve to enter the fossa cavity (Figs 5, 6). In all new species the abdomen is more elongate and extends posteriorly beyond the spinnerets (Fig. 3). Subapical spinnerets are also known in one species of *Delena* Walckenaer but which has an oval abdomen (pers. obs.). Subapical spinnerets have not previously been recorded in the Heteropodidae to my knowledge.

Further differences in *P. webberae* and *P. longbottomi* are not unique but noteworthy. Firstly, the setose posterior legs of the female *P. webberae* are distinctive (the poor condition of the only known male of this species excludes consideration here) having a brush-like appearance proventrally on the femur and tibia of leg IV and to some degree on the tibia of leg III. Although species of the *P. horni* group also have long setae on the ventral surface of leg IV (Hirst 1989) these setae are sparse. However long setae are more numerous on anterior legs of *P. tenuis* Hogg. Secondly, an elevation proximal to, and including the base of each leg spine, gives a tuberculate appearance (Fig. 4). This is most noticeable on the femora of *P. webberae* and can be seen in the male of *P. longbottomi* to a lesser degree. Lastly, the posterior eyes are smaller than in other species and, as the width of the posterior row is relatively the same, posterior eye interspaces are greater. Furthermore, the AME are largest in the male of *P. longbottomi*. Resolution of the AME size of the male *P. webberae* (see earlier) must await the availability of further material but certainly the AME of *P. webberae* are relatively larger than those of other known female *Pediana*.

Insemination ducts of the female and embolus of the male *P. webberae* have little more than one coil (Figs 6, 8) as in the embolus of the male *P. longbottomi*. Both are also similar in having the abdomen produced well beyond the level of the posterior spinnerets, in the carapace being low posteriorly (Fig. 10) and in the somewhat tuberculate legs. Males have a small embolic base and a relatively large subtegulum which, when viewed ventrally, is more exposed than in *P. temmei* and *P. paradoxa* and the *regina* group. However, carapace shape (Fig. 14) and coiling in the genitalia of the sister-species *P. temmei* and *P. paradoxa* are most similar to the *regina* group but both are more easily grouped with *P. webberae* and *P. longbottomi* in having anteriorly directed spermathecal sacs, an elongate abdomen and subapical spinnerets.

Acknowledgments

I wish to thank Dr G. R. Brown and Ms J. Webber (NTM), and Dr M. S. Harvey and Ms J. Waldock (WAM) for providing material. Dr M. Grasshoff (SMF) kindly loaned the material of *P. regina* var. Mr L. N. Nicolson commented on an early draft of the manuscript.

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